STRABISMUS SURSOABDUCTORIUS (WITHIN THE CONTEXT OF AN 18-YEAR ANALYSIS OF STRABISMUS SURGERY)

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Devoted to the memory of Dr. G. Divišová, the founder of modern Czechoslovak strabology

SUMMARY

STRABISMUS SURSOABDUCTORIUS (PUT INTO THE CONTEXT OF EIGHTEEN YEARS OF STRABISMUS SURGERY ANALYSIS)

Aim: To familiarize with the form of combined horizontal and vertical deviations and its development and put it into the context of eighteen years of strabismus surgery analysis.

Material and methods: During the period from 1996 to 2014, there were at the Department of Ophthalmology, 2nd Medical Faculty, Charles University and Faculty Hospital Královské Vinohrady, Prague, Czech Republic, E.U., operated on 2 248 patients due to the eye position misalignment. The surgery of dynamic (comitant) strabismus (esotropia, exotropia, vertical deviations and their combinations) was altogether performed in 81.7 % of patients. Out of them, horizontal-vertical deviations comprised 12.9 % - it was the strabismus sursoadductorius in 211 patients. Strabismus sursoabductorius (SAB) comprised 3.5 %; the initial type without excess of divergence (I-SAB) was established in 39 patients, and in other 43 patients it was the type already with the excess of divergence (E-SAB). The remaining surgeries were dealing with paralytic strabismus (14.7 %), and torticollis due to horizontal and torsional nystagmus (3.6 %).

Results: In the clinical picture of SAB dominated the elevation of the eyeball in abduction as well as in adduction, which was at the same time insufficient, negatively influencing the second phase of convergence. The divergent part of the deviation for far vision was on average in I-SAB 12 prisms (prism diopters)(Δ), and in E-SAB 30 Δ. The age of the patients at the time of the surgery was on average 12 years in I-SAB and 19.5 years in E-SAB. The difference between both evaluations was significant ($p < 0.005$), confirming the developmental relation. The I-SAB with the increasing age changes into the E-SAB. Between the two forms of this vertical–horizontal deviation was not significant difference in the minimal deviation at near (I-SAB 2.5 Δ and E-SAB 4.0 Δ). In the vertical part of the deviation was the difference even smaller (I-SAB 5.0 Δ and E-SAB 6.0 Δ). The simple binocular vision was maintained in less than half of the patients with I-SAB and roughly in one-fifth of the patients with E-SAB. In I-SAB, the stereopsis was confirmed in one half of the patients, and it was rare (1/10) in E-SAB. The examination on the Hess screen confirmed extorsion, but excluded incomitant relationship as well. This sursoabduction includes in itself some separate signs of dissociated vertical deviation (DVD), and adduction activity of overactioning inferior rectus muscle (IOOA), but does not represent either of these clinical entities. Recession of the inferior oblique muscle with its eventual simultaneous resection (anteposition) of the insertion at the level of inferior rectus muscle, in E-SAB supplemented by recession of the lateral rectus muscle was found as the ultimate surgical solution. The stereoscopic functions after the surgeries restored in part only, they were present altogether in two-thirds of patients with I-SAB and in two-fifths of patients with E-SAB. Substantially improved the convergence. The vertical deviation improved and eventual residual divergence was corrected by means of prisms.

Conclusions: The author expresses his own theory of this deviation's appearance. Presumed decompensated exophoria was transformed into intermittent form of exotropia, which was probably accompanied by appendant abduction of the inferior oblique muscle, because it was overacting at the same time. Insufficient adduction and convergence corresponded with that. In further development, the horizontal deviation developed into the excess of divergence with the maintenance of the inferior oblique muscle overacting (hyperfunction) and above-mentioned motility disorders. Post-operative position of the inferior oblique muscle insertion weakened its function in elevation and, simultaneously, the function of abductor transformed to function of adductor, and thereby decreased the divergence part of pathological misalignment of the eye position.

Key words: strabismus sursoabductorius, vertical deviation, horizontal deviation, exotrophia, hypertrophia, comitant strabismus, inferior oblique muscle recession

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INTRODUCTION

Vertical concomitant deviations in the pure form of tropia are infrequent. Far more common are composite forms, combining horizontal tropia with a vertical component. The most common form of combined horizontal and vertical deviation is strabismus sursoadductorius concomitans. This concerns esotropia in which one or both eyeballs rotate upwards in adduction, in the direction of function of the inferior oblique muscle. It is considered that this represents a state which is conditional upon the character of the muscles. The inferior oblique muscle contains a smaller angle with the visual axis,

and is more robust than the superior oblique muscle (homolateral antagonist). Overall its elevating effect is more pronounced than the depressor effect of the superior oblique muscle. The pronounced hyperfunction of the inferior oblique muscle must be resolved primarily, or additionally in the second phase [8]. The main aim of this report was to concentrate on the analysis of a rare form of vertical-horizontal deviation, which incorporates exotropia and hypertropia, to assess its development on the time axis, the options of surgical solution and to express a definition thereof within the context of overall strabismus surgery. In the last twenty years we have not found detailed data on this vertical-horizontal deviation in PUBMED.

Study cohort

We conducted a retrospective study of strabismus surgery at the Department of Ophthalmology at the Královské Vinohrady University Hospital in Prague covering the period from 1 January 1997 to 31 December 2014. We thus linked indirectly to the previous ten-year analysis from 1997 to 2006, which dealt primarily with an analysis of the use of individual surgical techniques for individual age groups of patients with dynamic and paralytic strabismus [20]. The individual surgical procedures were described in detail, including the operating schemas [19]. In this study we focused on individual diagnoses and their surgical solution in relation to vertical-horizontal deviations.

Surgery for dynamic strabismus comprised a total of 81.7% of procedures (table no. 1). The relatively large number of divergences was conditioned by its consecutive form, for which the patients were sent mostly as adults to our department following previous retropositioning of the inferior rectus muscles in childhood. In the case of concurrent hypertropia, retropositioning of the inferior oblique muscle alone was performed in order to strengthen convergent strabismus on 94 patients, or was performed in combination with a procedure on the rectus muscles on a further 56 patients. Weakening procedures using a strengthening effect for convergence on the inferior oblique muscle were indicated in total for 22.4% of exotropias. In the case of independent hypertropia without horizontal deviation (even in anamnesis), the surgical procedure was selected according to the condition of convergent strabismus. In cases of perfect convergent strabismus in the first and second phase, partial myotomy of the inferior oblique muscle was indicated by electrocauter according to Romero – Martinez. For patients in whom this function was insufficient, retropositioning of the inferior oblique muscle was used according to Parks, and only once myectomy of the inferior rectus muscle. In the case of sporadic hypertropias only in the first ten years of the study, retropositioning of the inferior rectus muscle or antepositioning of the superior rectus muscle was used.

Vertical-horizontal deviations represented 15.8% of all operations for dynamic types of strabismus, and were divided according to the form of the horizontal deviation. Strabismus sursoadductorius (combination of esotropia and hypertropia) was diagnosed in 211 patients. Of this number, weakening surgery was performed on the medial rectus muscles using the elongation method according to Gonin – Hollwich, together with a procedure on the oblique muscles with the help of partial myotomy by electrocauter according to Romero – Martinez, in 115 cases. In the remaining 96 patients the procedure on the inferior oblique muscle was supplemented in the second phase, only after the primary weakening procedure on the horizontal muscles due to the persistent vertical component. The actual surgical technique was designated according to the same principle as in the case of independent hypertropia. Vertical-horizontal deviation incorporating divergence was detected in 79 individuals (i.e. 4.3% of all dynamic strabismus operations). An evaluation thereof is presented below.

Due to the complexity of the analysis of the individual diagnoses, the issue of paralytic strabismus and solution of orcular torticollis due to nystagmus was summarised in table no. 2. Only primary procedures were included, supplementary operations were allocated to the individual forms of horizontal or vertical non-incomitant strabismuses.

RESULTS

Vertical-horizontal deviations comprised 12.9% of the total number of all operations, thus one eighth. We have presented an evaluation of strabismus sursoadductorius above. We divided strabismus combining divergence and hypertropia into two types. We have presented the individual differences in the anamnestic and strabological data between the initial form of strabismus sursoabductorius (U-SAB) without excess divergence and the form with excess divergence in table no. 3. The average age of patients at the time of indication for surgery and its performance was 12 years in the case of I-SAB and reached practically 20 years for E-SAB. The difference in age on the basis of a statistical evaluation (a Student two-tailed T-test was used) was significant (p 0.001). This confirmed our hypothesis: It concerns a related form of strabismus which develops with age. The representation of both sexes was identical in the case of I-SAB, whereas in E-SAB the number of females was practically double the male population. The unilateral form of this vertical-horizontal strabismus was registered practically in 2/3 of cases of I-SAB, whereas in E-SAB the alternating type predominated. The deviation in the horizontal direction for distance vision in the case of I-SAB was 12 pdpt, whereas for E-SAB it was on average 30 pdpt, which was statistically significant (p 0.004). This fact supplemented our assumptions concerning the development of this type of strabismus: E-SAB is a further developmental degree of this vertical-horizontal dissociation, ensuing from and following the initial form of SAB. The horizontal deviation for close-up vision did not differ markedly between both forms, in patients with I-SAB it was on average 2.5 pdpt and for E-SAB 4 pdpt. This applied respectively also to the vertical component of the deviation, since hypertropia among patients with I-SAB was 5 pdpt, and 6 pdpt for patients with E-SAB. There was no statistically significant difference between the two forms in these two deviations (p 0.063 and p 0.092 respectively). The main clinical picture in the sense of vertical-horizontal deviation which was manifested in subsequent V-syndrome was elevation of the affected bulb in abduction and in adduction. The eyeball did not draw completely into addu-

Table no. 1 – Types of comitant strabismus

Type of Comitant Strabismus	Number
Esotropia	808
Exotropia	669
(total horizontal strabismus)	1487
Hypertropia	64
Hypotropia	6
(total vertical strabismus)	70
Dissociated vertical and horizontal deviation	290
TOTAL	**1837**

ction, which was not manifested until the second, insufficient phase of convergent strabismus. By contrast, the first phase of convergent strabismus was indicated. It ensued from an orthoptic analysis of spatial functions that simple binocular vision (SBV) was preserved in almost half of patients with I-SAB, whereas this applied to only 1/6 with E-SAB. The inhibition of one eye was markedly represented in both forms, from which there emerged an alternation of perception, more frequently in the case of E-SAB, in 1/3 patients. Vertical-horizontal diplopia was identified twice only in this form (e.g. patient no. 2). Stereopsis was constant in more than half of the patients with I-SAB, but only in 1/10 in the case of the form with excess divergen-

Table no. 2 – Types of incomitant strabismus and surgical proce-

Diagnóza	type/phase	Surgical techniques	subtotal	total
Paresis n. III	Phase 1	Resection RI and Myotomy RE (Gonin-Hollwich procedure)	15	22
	Phase 2	Transposition OS (Scott procedure) and surgery of ptosis	7	
Paresis n. IV	Phase 1	Weakening OI (Romero-Martinez procedure) Plication OS 14 - 18 mm	104	
Paresis n. VI	Phase 1	Myotomy RI (Gonin-Hollwich procedure) and Split-tendon transfer (Jensen procedure)	38	
Double elevatory palsy	Phase 1	Cul-de-sac approach to adjustable strabismus surgery	46	71
	Phase 2	Full-tendon transfer (Knapp procedure)	25	
Duane´s retraction syndrome	I.	Myotomy RI (Gonin-Hollwich procedure)	53	56
	II.	Recession RE	3	
Brown´s syndrome	basal	OS silicone expander 8 mm	29	38
	superstructure	Recession OI (Parks procedure) contralateral antagonist	9	
Nystagmus causing compensatory head posturing	horizontal	Kestenbaum procedure for nystagmus horizontalis	57	83
	vertical	Weakening OI, Disinsertion tendon OS (Harado-Ito procedure)	25	

Table no. 3 – Analysis of strabismus sursoabductorius

Characteristic - strabismus sursoabductorius:	initial without divergence excess	with divergence excess
Number of patients	36	43
Representation by gender (men : women)	18:18	.28:15
Age range in years	3 to 33	4 to 65
Average age at surgery (standard deviation)	12.0 (8.6)	19.5 (13.6)
Verification - side representation	unilateral (64 %)	alternating (57 %)
Refraction in terms of requiring Correction	myopia and presbyopia sporadically	
Visual acuity	side alignment, maximum decrease of 0.7	
Variation in distance - range (pdpt)	6 to 20	22 to 45
Variation in distance – diameter (standard deviation)	12 ± 4	30 ± 7
Deviation in close up - range (pdpt)	0 to 12	
Deviation in close up – diameter (standard deviation)	2,5 ± 3	4 ± 2,5
Altitude deviation - range (pdpt)	4 až 14	4 až 20
Altitude deviation – diameter (standard deviation)	5 ± 2	6 ± 3
Convergence	Phase 1 functional and Phase 2 insufficient	
Simple binocular vision (stereoscope)	46%	16%
Stereopsis (Lange, Randot)	58%	9%

ce, which in addition was sporadically unstable. In the last three years we also examined torsion on a Maddox cross. After essential alignment of the horizontal deviation using prisms for alternating forms, the result was not reliably reproducible, in the case of the unilateral form excylotorsion was unstable. Favourable results of the diagnosis of torsion were the isolated findings on the Hess screen. We designated verification of the operation for both forms of SAB on the same principle. In the alternating type, the horizontal deviation was larger than in the unilateral form, as a result of which we always operated on both eyes. For I-SAB we chose independent retropositioning of the inferior oblique muscle, mostly with antepositioning of a new tendon to the level of the inferior rectus muscle. In the case of E-SAB we supplemented this procedure with retropositioning of the lateral rectus muscle by 6 mm. In the postoperative period primarily the vertical deviation was aligned, the residual horizontal component was only sporadically resolved by prismatic correction. Spatial vision improved in both forms to a different extent. Patients with original I-SAB attained SBV in stereopsis in practically 2/3 of cases. In the case of E-SAB the improvement was less marked. Overall SBV was approximately detected in 2/5 patients, and constant stereopsis in 1/3 of patients following a surgical solution. An interesting feature of the cohort was the detection of I-SAB in two non-identical twins aged 8 years. In order to supplement the clinical units we included three case reports: of the first and one of the last patients of the cohort, together with a patient with acute form substantiated by a typical finding on a Hess screen.

Patient no. 1. We operated on a twenty year old woman in April 1999 for exotropia, which was accompanied by hypertropia in both horizontal gaze positions in the left eye. The most pronounced vertical-horizontal dissociation was upon incomplete adduction of the left eye (fig. 1AB).

eight year old man in February 2011 for vertical divergent strabismus. In childhood amblyopia was diagnosed in the left eye, which was treated by occlusion of the right eye (according to current refraction, hyperopia was probably more pronounced in the left eye than in the right). From the age of seventeen worsening of position began to appear rather in the right eye, with diplopia in distance and close up gaze, maximally in upward gaze and minimally downward. At the first examination the patient fixed predominantly LE in distance gaze, RE in exotropia -22 pdpt and 8 pdpt hypertropia. Upon alternation of fixation there was In distance gaze in a cover test -15 pdpt and from above 3 pdpt close up practically parallel (- 4 pdpt), in AKT there was no pronounced accentuation of the deviation, convergent strabismus – only in the 2nd phase, balance LE. Orthoptic analysis: examination on stereoscope, Bagolini, W.sv. close up demonstrated SBV, only in distance gaze for W.sv. suppressed LE, troposcope: -5 degrees and 1 degree hypertropia LE. VRE = VLE 1.0 nat. and J. no. 1. We de-

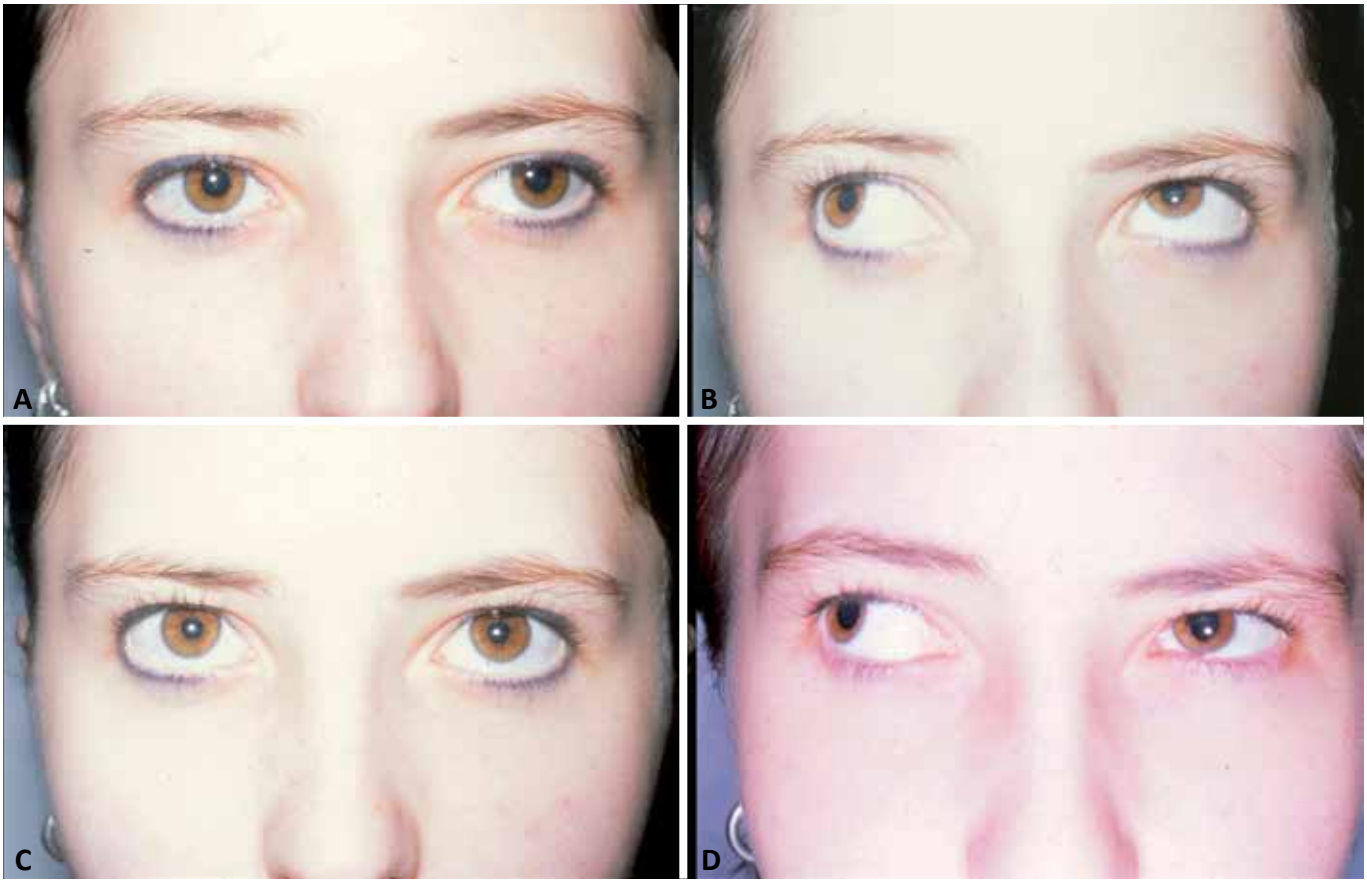

Fig. no. 1. 20 year old patient with initial form of strabismus sursoabductorius – A,B: preoperative position and dextroversion of eyeballs and C,D: postoperative position and dextroversion of eyeballs

cided to treat the condition by unilateral retropositioning of the inferior oblique muscle with antepositioning of the tendon to the level of the inferior rectus muscle in the left eye. After surgery the position and motility of the left eye was completely corrected (fig. 1CD). In parallel position the orthoptic analysis demonstrated: troposcope 0 st., SPP, fusion 1st and 2nd degree present, width of fusion -4, +9 degrees and also W.sv. in distance gaze SBV. We retrospectively amended the diagnosis to strabismus sursoabductorius in left eye – initial type.

Patient no. 2. We operated on a twenty exotropia of secondary hypertropia in the left eye of the same size. In close up gaze the height component rather dominated, since microexotropia was within the range of -4 to -6 pdpt. In motility there was evident height dissociation of RE as against LE both in dextroversion and in sinistroversion, upon adduction both eyeballs did not draw fully (fig. 2 above). Alternately the patient did not engage the eyeballs in the 2nd phase of convergent strabismus. Oprthoptic analysis: troposcope – objective angle -14 degrees and 9 detrees hypotropia LE, subjective angle only momentarily similarly, stereo: diplopia vertical-horizontal, with corresponding cyclotropia in left eye, also on H.B test and Hess screen, in test with red filter exodeviation -20 to -25 pdpt, but hypertropia up to 14 pdpt. The characteristics of the patterns on the Hess screen were analogous in both eyes, since they were of the same size and shape, which did not confirm an incomitant character. In the direction of vertical-horizontal dissociation they were oriented opposite one another and the divergent direction of both vertical axes of the patterns attested to excyclotorsion (fig. 2 below. An examination on a Maddox cross after alignment of the horizontal deviation using prisms presented unstable excylotorsion of 2 to 6 degrees in the right eye only. VRE 1.0 and J.no. 1 s 1.0/30 and VLE 1.0 and J.no. 1 nat. With regard to the alternating character of both pronounced exotropia and pronounced hypertropia in the right eye we supplemented retropositioning and antepositioning of the inferior oblique muscle in the right eye with retropositioning also of the inferior rectus muscle in the left eye by 6 mm. After surgery we applied prismatic correction –1.0/30 = 6 pdpt/0 degrees in the right eye and 4 pdpt/270 in the left eye. With this correction the patient no longer stated diplopia in January 2014, in a cover test only extensive motion from divergence and hypertropia in the RE was evident. Orthoptic analysis: stereo connected, but stereopsis (Randot) was lacking, on a Hess screen practical alignment of patterns was diagnosed. We classified the patient into a the group with E-SAB on the basis of development of verti-

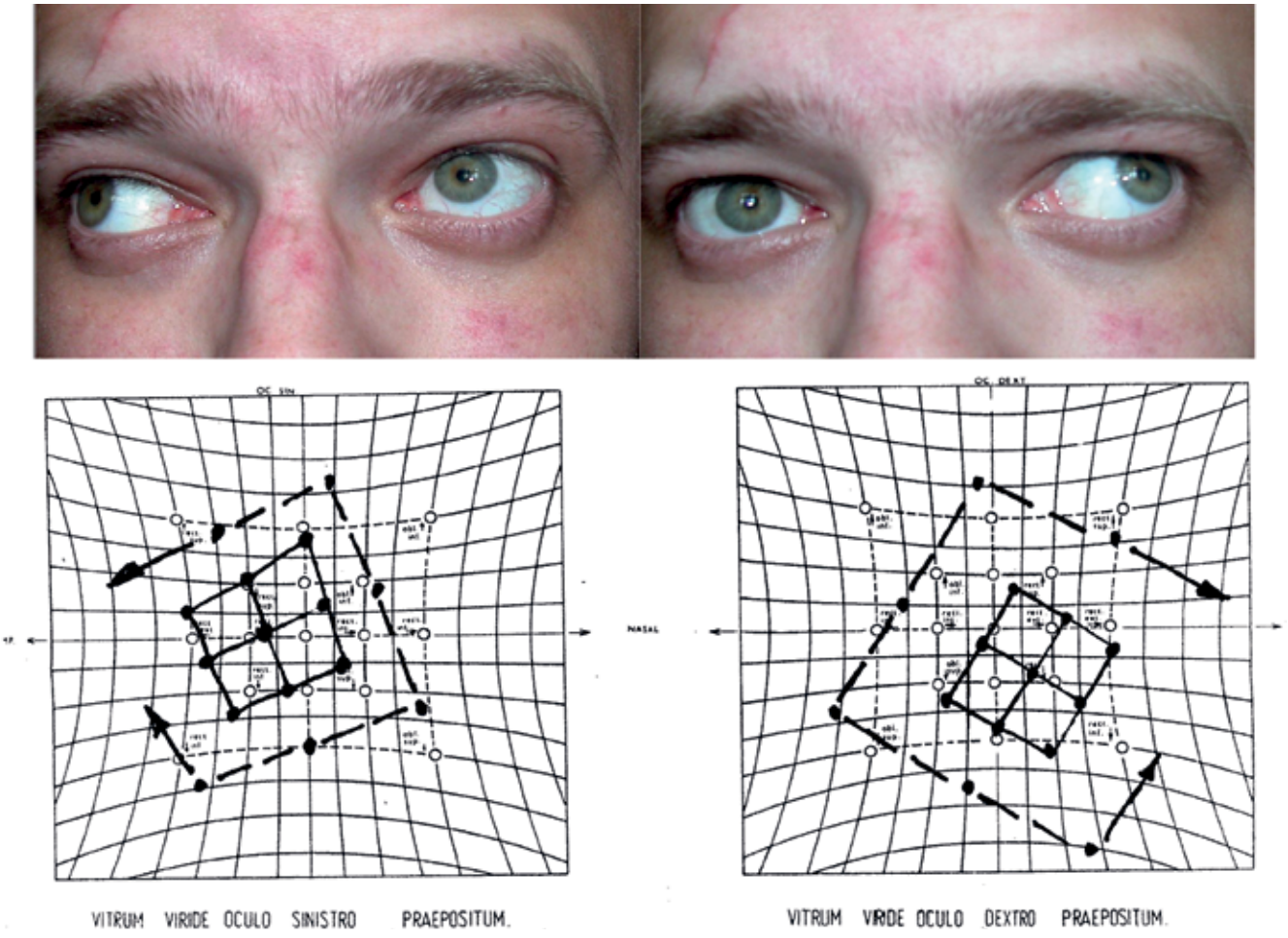

Fig. no. 2. 28 year old patient with excess divergence in strabismus sursoabductorius: preoperative motility of eyeballs in versions (above), Hess screen excluding incomitant state (below)

cal-horizontal dissociation with incomplete adduction and excyclotorsion.

Patient no. 3. We operated on an eight year old girl in February 2014 for I-SAB in the right eye. The patient's face was skewed to the left in view, in primary gaze position to distance -10 pdpt and unstable upward movement 10 pdpt (fig. 3A), close up vision minimal deviation -2 pdpt and from above 4 pdpt, but in alternation up to 10 pdpt, in which accentuation in close up gaze was minimal, convergent strabismus in the first phase was indicated, but in the final phase released LE. In motility there was evident vertical dissociation in sinistroversion and dextroversion in upward gazes,

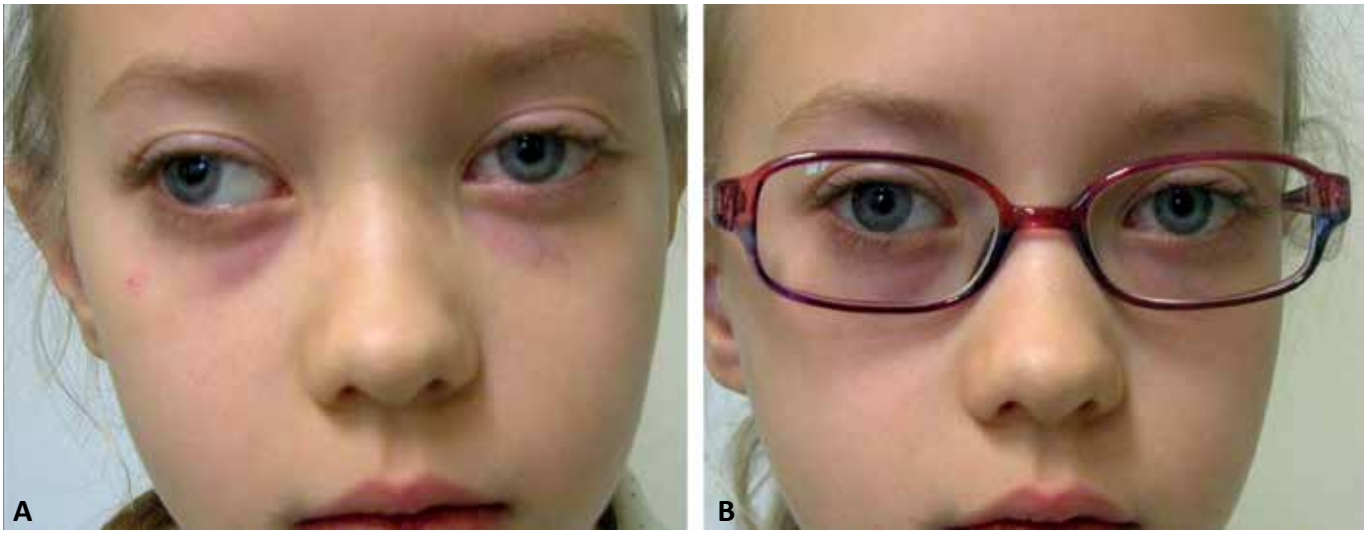

Fig. no. 3. 8 year old patient with initial form of strabismus sursoabductorius – A: position of eyeballs before surgery and B: position of eyeballs after surgery

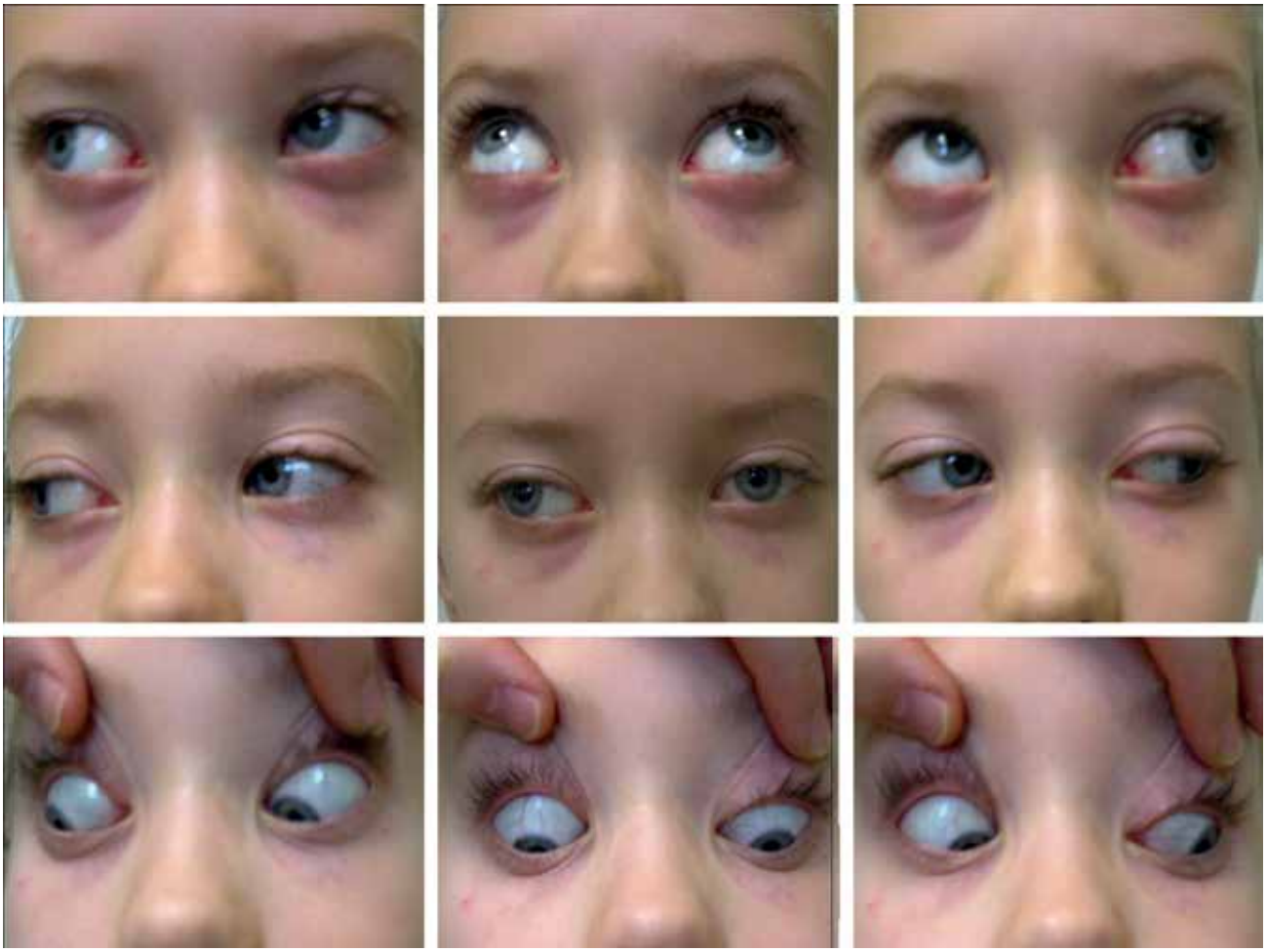

Fig. no. 4. 8 year old patient – analysis of motility in all gaze positions in strabisumus sursoabductorius

in which V-syndrome was evident, upon downward gaze and simultaneously laterally without height dissociation (fig. no. 4). Orthoptic analysis: stereo connected, Randot +, Lange partially, troposcope: subjective angle connected at -4 degrees and 5 degrees hyper, later the image increased to 10 degrees hyper, objective angle -6 degrees and 10 degrees hypertropia, all in right eye. We did not indicate examination on a Maddox cross and Hess screen due to poor quality co-operation conditioned by the patient's age of 7 years, which rendered results difficult to reproduce. VRE 0.7 s -5.5=-0.5/85 and J.no.3, VLE 1.0 s -5.0=-1.0/170 and J.no.1. We decided to treat the condition by unilateral retropositioning of the inferior oblique muscle with antepositioning of the tendon to the level of the inferior rectus muscle in the right eye. At a follow-up examination three months later the position of the eyeballs was parallel in close up gaze (fig. no. 3B), in distance gaze in a cover test only slight exodeviation -4 pdpt without height component, motility loose, stereofunctions were absolutely within the norm.

DISCUSSION

SStrabismus sursoadductorius concomitans may be of an intermittent or constant character, and ranks among non-dissociated vertical deviations. Its primary form is attributed to local anatomical ratios in the orbit. The secondary form is an echo of incomitant tropia which has become dynamised over time, but vertical dissociation has remained. Alternating sursumduction is not classic vertical heterotropia. Upon covering of the eye this veers upward, and after uncovering spontaneously returns to the original position, but secondary deviation in the opposite direction, i.e. downwards, is not manifested here. This dissociated vertical divergence, also referred to as DVD, is generally a component of congenital esotropias (Lange syndrome). To date the etiology is unclear, it is thought to be a malfunction of innervation. According to Duke-Elder it is a manifestation of unbalanced innervation activity of the co-ordination areas which control vertical movement of the eyes [9], thus a supranuclear malfunction and not a peripheral affliction. An important unit for assessment of vertical-horizontal dissociation and motility is IOOA, which is described in 2/3 infantile esotropias [3]. Important observations concerning DVD were provided by Helveston's electro-oculographic study [16]. Upward movement is slow, within the range of 2 to 40 degrees per second (d/s) in comparison with saccadic aligning movements within the range 200 to 400 d/s. When the eye is covered downward movement accelerates to 10 to 20 d/s. All these movements are performed without any identifiable functional gain. Upon DVD the occluded eye in sursumduction attains a maximum by 15 degrees or more within a few seconds, but later sursumduction decreases and is identical in comparison, in speed and amplitude, with the fixing eye. The drop in hyperdeviation of the occluded eye is dependent upon the length of occlusion. The amplitude of the upward movement upon DVD is practically the same in the primary gaze position as in abduction or adduction, but the possibility of an increase of one of the components of movement is not excluded. The direction of movement is of more importance than its speed or amplitude, which is a typical feature of DVD [16]. From this it ensues that there is a concomitant and not a paralytic relationship in DVD. Occlusion of one eye triggers two types of deviations: Partially this is heterophoria – the occluded eye veers in a horizontal or vertical direction, or into a torsional position. Fusion maintains the parallel position within the framework of binocular fixation. In second place are dissociated deviations, which are divided into horizontal, vertical or torsional. These can be detected in infantile strabismus. The deviation in the fixing eye is always smaller than the deviation of the occluded eye. Dissociated extorsions are always connected with bilateral elevation in the primary gaze position. Dissociated deviations in infantile strabismus are linked to further phenomena, such as horizontal or rotational nystagmus and asymmetrical optokinetic nystagmus. Fixation is preferentially in adduction with incyclotorsion [29]. In patients with an early originating defect of binocular vision, occlusion of one eye and concentration on the other fixing eye generates an unbalanced impulse for the vestibular system. The result is lateral nystagmus with a cyclovertical component. This mechanism, which is known as DVD, generates an irreversible elevation and extorsion of the paired eye. Cycloversion with vergence helps block nystagmus in favour of an improvement of visual acuity in the fixing eye [14]. A significant influence is exercised here by the functions of both oblique muscles, the inferior oblique muscle predominates due to its more robust muscle structure in comparison with the superior oblique muscle [9]. Suppression of one eye conditions its elevation and extorsion of the eye (inferior oblique muscle) and secondary depression and intorsion (superior oblique muscle) in the paired fixing eye [5]. A correlation can be found in A- and V- syndrome, increased activity of the superior oblique muscle is linked with A-syndrome, whereas increased activity of the inferior oblique muscle is linked with V-syndrome [8], which is an argument supporting the presence of V-syndrome in connection with IOOA [3]. On the basis of Hering's law, the elevators of the fixing eye are toned, which further accentuates DVD in the subordinate eye [12], a more significant role is played by the superior rectus muscles, whereas the oblique muscles are of more fundamental importance for torsional movements. Early surgery for infantile esotropia helps strengthen binocularity and prevent blunt-sightedness, and at the same time reduces the incidence and development of DVD in this type of strabismus. If surgery is performed at a later age, the possibility of development of DVD increases [2]. DVD is therefore characterised by elevation also in abduction with excyclotorsion, which may be provoked by occlusion, and in the contralateral eye there is corresponding hypertropia [3]. Intermittent extropia accompanied by DVD is characterised by an early beginning of strabismus with poor stereopsis, which could indicate its influence on the development of DVD in these patients [22]. The potential synergy of IOOA and DVD upon the occurrence of sursoadduction can be explained by means of the similar cause of both clinical units. Decorrelation of monocular signals in heterotropia is considered to be

the cause of disbalance of tonic innervation. This in the case of vertical ocular movements causes pathological "sensory torsion". For this reason dynamic torsion is typical of dissociated hypertropia in DVD. This usually concerns extorsion conditioned by the function of the inferior oblique muscle, similarly as in the case of [15]. It is necessary to remember that it is frequently difficult to differentiate between DVD and IOOA [3]. In general it is possible to state that the etiology of origin of vertical deviations including DVD is not concluded, and for the moment remains within the realm of hypothetical considerations of leading strabologists, as attested to by the above observations and quotations.

Alternating exotropia with a larger horizontal deviation may also have a recorded vertical deviation in the sense of elevation in abduction, the condition has been indicated as strabismus sursoabductorius [9] without stating the original literary quotation. We confirmed this theory in our study and furthermore elaborated upon it by two developmental phases, in which incipient I-SAB later passes into the form of E-SAB, i.e. with excess divergence. Development was documented between both types on the basis of statistical significance in the increase in age of the operated patients and in the progression of the size of divergence. The difference in the deviation in distance and close up gazes was larger than 15 pdpt in the later type of SAB, which confirmed a finding of right excess divergence [9]. Initially we did not consider these developmental degrees, we believed that only extropia was accompanied by hypertropia in the sense of DVD. Intermittent exotropia may exist also in IOOA [3]. Only retrospectively did we amend the terminology approximately three years ago [18] due to stagnant adduction and insufficient convergent strabismus, which are not described in IOOA. I-SAB is very similar to IOOA with intermittent exotropia. The possibility of a relationship between horizontal deviation with hypertropia, whether this concerns esotropia or exotropia is stated by the latest textbook on paediatric ophthalmology in our region [13]. A modern American monograph is focusing on the same issue [35], but neither of the monographs states SAB. Both consider only a combination of horizontal deviation (divergence) with DVD [13, 35]. In SAB the condition of elevation in abduction is constant without dissociation, which combines divergence and hypertropia and is thus a simultaneous manifestation of vertical and horizontal deviation. It is therefore parallel with strabismus sursoadductorius, but both strabismuses differ fundamentally from one another in the direction of the horizontal component. The effect of the inferior oblique muscle is manifested in both. In the case of strabismus sursoadductorius it predominates around the more robust force base of the inferior oblique as against the superior oblique muscle [9], and has a significant influence in IOOA [3]. The absolutely distinct elevation property of this muscle in SAB is not fully applied, since here there is incomplete adduction due to its accompanying abduction property.

Upon examination of strabismus sursoadductorius in both eyes, if the resulting pattern of the Hess screen shows the same size and internal structure, muscle paralysis or diplopia are excluded. If the patterns are merely shifted without changes of size and shape, this attests to convergent, concomitant strabismus, in which the shifts determine the given type of strabisumus on the horizontal and vertical axes. Angular rotation of the patterns attests to cyclotropia or phoria, upon divergence of the vertical axes for external rotation and upon their convergence for internal rotation [25]. We recorded a similar finding also in the case of SAB. Although the size of the patterns differed slightly, the larger secondary square upon secondary deviation could have been conditioned by diplopia. A classic incomitant relationship was not confirmed, but the finding approached concomitance. A torsional mechanism was also demonstrated here in the clinical picture of SAB, since the vertical axes in both eyes were in divergence, this concerned excylotorsion. An examination of cyclodeviance using a Maddox cross, which serves for assessment of malfunction of muscle balance in distance gaze [9] did not produce representative results, the reason for this was the pronounced hyperfunction of the inferior oblique muscle, since torsional movement is limited also in the case of IOOA [3, 33].

In comparison with the previous ten-year study [20], we confirmed that for consecutive exotropia also it is appropriate to supplement a surgical procedure on the horizontal muscles for weakening of the inferior oblique muscle by retropositioning, since this strengthens convergent strabismus [21]. Upon examination of the relationship between stereofunctions and retinal correspondence before and after a surgical procedure in the case of intermittent exotropia on four hundred patients, the binocular functions which were already in a balanced position before surgery were restored or strengthened in the majority of cases. Normal retinal correspondence was present in almost half of the patients before surgery, whereas after surgery it was restored in a further quarter. It was precisely in the case of patients with abnormal retinal correspondence, in which vertical deviation was present, that the assumption was expressed that this could develop before the anchoring of binocular functions [30]. Intermittent exotropia (35 – 53 pdpt) with associated hypertropia (2 – 14 pdpt) may imitate paresis of the superior oblique muscle. In a group of 93 patients, foveolar extorsion was demonstrated with dysfunction of the oblique muscles and a positive Bielschowsky test. The condition was resolved successfully only by a procedure on the horizontal muscles [7]. In our study cohort we did not operate on solitary intermittent extropia. We surgically treated only the next degree of development of divergence, namely the clinical picture of excess divergence, in which we observed a height component in the above-stated cases (table no. 3).

In the 1980s the suitability of surgical treatment of DVD with the help of resection of the inferior oblique muscle was considered, in which the procedure rarely succeeded in absolutely resolving this deviation, but frequently had a cosmetic effect [30]. Upon the use of this method there is a danger of scarring, with subsequently mechanically generated hypertropia – adherence syndrome, described by Parks [9]. Classic independent retropositioning of the inferior oblique muscle according to Parks found larger application [26], in which a new muscle tendon is fixed by its limbal portion 3 mm beneath the tendon of the inferior rectus muscle and 2 mm outwardly. "Anterior antepositioning" of the inferior oblique muscle or further modifications of the procedure included also in the name of the

procedure have so far been demonstrated to be an effective method of treating DVD for twenty years [6, 23]. This operation has found application also in our region [11, 33]. The surgical procedure has been known for over fifty years. It concerns a measured retropositioning of the inferior oblique muscle within the range of 8 to 14 mm, in which a new tendon of this muscle is shifted or antepositioned to the level of the inferior rectus muscle [9]. The principle combines actual weakening of the hyperfunctioning muscle with change of its function, in which the abductor becomes an adductor [10] through the change of position of the tendon in front of the equator of the eyeball. The author is the American ophthalmologist, professor Walter H. Fink (1895 – 1969), who made a significant contribution to the development of strabology thanks to his exceptional knowledge of the anatomy of the orbit. Professor Fink wrote 56 articles and two textbooks (1951 and 1962) on this theme [34], which was unusual for the time. He was the predecessor of the far better known experts on issues of strabismus such as professors E. M. Helveston, M. M. Parks and G. von Noorden. The shift of the inferior oblique muscle may cause anti-elevation syndrome, i.e. hyperfunction also of the contralateral inferior oblique muscle. The condition requires a supplementary procedure also on this muscle [12]. Alleviation of anti-elevation syndrome can be achieved by more pronounced lateralisation of fixation by 4 to 5 mm from the tendon of the inferior rectus muscle, whilst retaining the same height level, but with the knowledge that the effect of correlation of DVD will be lower [28]. We recorded this condition in two patients with unilateral form of SAB. Despite this we did not change the surgical technique. DVD surgery has also included the Faden operation recommended by Cüppers for alternating hyperphoria (the former name for DVD) since 1974. This concerns fixation of the muscle by retro-equatorial sutures, thus creating a second tendon and artificial paresis, which does not change the primary gazes position of the eye [9]. In the above-stated monographs, the Slovak author recommends this procedure (retro-equatorial myopexy) for DVD [13], but the American authors do not state it for DVD, and adjustable sutures also do not rank amongst their indications [36]. Further solutions were sought. Mild forms of vertical-horizontal deviations can be corrected with the help of prismatic correction supplemented by a spherical value, weakening or strengthening the accommodating convergent mechanism [19, 27]. Vertical-horizontal deviations, whether this concerned esotropia or exotropia, were also treated by transposition operations with the help of a shift of the tendons using the abduction or adduction property of the vertical muscles [17]. In the case of DVD accompanied by the A-form of strabismus of a small extent, retropositioning of the superior rectus muscle was applied, but in the case of larger degree A-syndrome the procedure had to be supplemented with weakening of the oblique muscles (tenectomy of the superior oblique muscle and if applicable also retropositioning of the inferior oblique muscle) [32]. In the case of patients with DVD which was accompanied by unilateral amblyopia, the horizontal component of the deviation was not concurrently treated. An alternative procedure was draping of the inferior rectus muscle by means of plication. The extent of the horizontal deviation in exotropia was weakened, but conversely in the case of esotropia was increased [1]. In our cohort, antepositioning in connection with retropositioning of the inferior oblique muscle to the level of the tendon of the inferior rectus muscle simultaneously pronouncedly weakened the present extropia. We confirmed strengthening of convergence previously also by simple retropositioning of the inferior oblique muscle, in contrast with its partial myotomy by electrocauter, which does not influence the horizontal position of the operated eyeball [21]. If the inferior oblique muscle is transposed to the level of the equator it is then possible to resolve DVD successfully, and at the same time the horizontal deviation in infantile esotropia or exotropia is not influenced [31]. For weakening of the inferior rectus muscle in E-SAB we chose its retropositioning only for the reason of limiting scarring upon a simultaneous surgical procedure on the inferior oblique muscle. The correction of binocular functions after weakening procedures on the inferior oblique muscles or lateral rectus muscles was influenced primarily by the age of patients at the time of surgery, we recorded correction in pre-school age and maximally up to the age of 8 years, which corresponds with the knowledge concerning the development of SBV in stereopsis [9]. The number of SAB operations performed on 79 patients was closest to the number of surgical treatments of torticollis for nystagmus on 86 patients in the same eighteen-year period.

CONCLUSION

In a comparison of three clinical units, namely DVD, IOOA and SAB, certain differences emerge:

1. There is simultaneous elevation in adduction and abduction in DVD and SAB, whereas in IOOA there is elevation only in adduction.
2. DVD is predominantly of a concomitant character, despite the fact that it concerns a supranuclear malfunction, SAB does not have an incomitant basis and is analogous to strabismus sursoadductorius, IOOA is a non-dissociated vertical deviation, but with pronounced elements of incomitance.
3. There is an association with V-syndrome in IOOA and SAB, but not in DVD, where there may be A-syndrome.
4. Torsion is present in DVD and SAB, but not in IOOA.
5. SAB is always characterised by stagnant adduction, whereas in DVD it is mostly loose, and in IOOA is always loose.
6. Convergent strabismus is impaired in SAB, in DVD it depends on the type of horizontal deviation and is good in IOOA.
7. Corresponding hypotropia is not in abduction in DVD, is present in IOOA and may appear in SAB.

The theoretical basis of SAB could be progressive four-degree development of exotropias with co-participation of hyperfunction of the inferior oblique muscle. Presumed decompensated exophoria passes into intermittent form of exotropia, which was probably supported by the accompanying abduction property of the inferior oblique muscle, because it was simultaneously hyperfunctional. In the further course, the horizontal deviation was accentuated into the form of excess divergence, but the hyperfunctional quality of the inferior oblique muscle remains unchanged. The successful surgical solution, incorporating above all retropositioning of the inferior oblique muscle with its simultaneous antepositio-

ning to the level of the inferior rectus muscle, argues in favour of mutual co-participation of both vertical-horizontal components of sursoabduction. The postoperative position of the tendon of the inferior oblique muscle weakened its elevation function and at the same time transferred the function of the abductor to the position of an adductor, thus reducing the divergent component of the pathological position of the eye.

Together with this there was an exclusion of the applicable influence on the superior rectus muscle, which applies for DVD, as a pronounced elevator, but with a weak intorsional component. This sursoabduction incorporates only certain individual signs of dissociated vertical deviation (DVD) and adduction activity of the hyperfunctional inferior rectus muscle (IOOA), which represents a separate clinical unit..

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