Infantile Esotropia: Emergence of Binocular Function years after surgery

I. Reich-d'Almeida[1], C. Costa Lança[2,3], F. Reich-d'Almeida[1]

[1]*Clinica Oftalmológica Dr. Reich-d'Almeida, Lisbon, Portugal*

[2]*Lisbon School of Health Technologies, Lisbon, Portugal*

[3]*Centro de Investigação em Saúde Pública, Escola Nacional de Saúde Pública, Universidade Nova de Lisboa, Lisbon, Portugal*

ABSTRACT: *Purpose.* To demonstrate that in surgically treated infantile esotropia (IE) patients, it is possible, after a very long therapy and follow-up period, to achieve functional rehabilitation well above the conventionally accepted age for sensorial recovery. *Methods.* In a retrospective observational cohort study, 45 IE patients were enrolled. Inclusion criteria comprised previous surgery, follow-up of at least six years, the emergence of binocular function (BF) after nine years of age and maintenance of a monofixation syndrome (MS), using prism and optical regular re-evaluation. *Results.* The time-lag between the first appointment and first signs of binocularity varied between 5-16 years (10.31 + 2.74) and age of BF appearance from age 9-16 (mean age of 12.31+1.84 years). Follow-up lasted between 6-36 years (mean 16.62+ 6.68 years). From 45 patients, stereopsis was found in 31.1% (n=14), 62.2% (n=28) attained motor and sensory fusion in real space, and simultaneous perception (SP) without fusion was detected in 6.7% (n=3). Near stereoacuity ranged from 200- 40" of arc with a mean of 88.57 + 55.50 and 22.22% (n= 10) presented stereoacuity of < 70". Distance stereoacuity values were 400-60" (mean of 176 + 135.20).*Conclusion.* Operated IE cases may achieve BF way above the consensual age limit. In this study, BF sometimes arose as much as 16 years later which is epidemiologically relevant in this condition and can be far-reaching in consequences for the patient's social role and integration, thereby for his quality of life. It also reinforces the notion of brain and visual system plasticity at a much later age.

KEYWORDS: Binocular vision; infantile esotropia; late binocularity in squint; neural plasticity; stereopsis.

1 INTRODUCTION

The first goal of any squint treatment is realignment with full sensorial rehabilitation. A crux problem in IE has been, however, recovery of BF. Scholarly attention has been given to the age of surgery, and it is commonly taken as a dogma that functional results depend upon intervention before the age of 6-24 months, preferably six months[1,2]. In recent years, from neuroscience as from the clinical ground, opposing views did quote immediate post-operative binocularity following IE surgery in older age groups [3-7]. Though plasticity of the visuomotor process, neuroadaptation potential and the building up of new neurons, all remain controversial.

In this cohort, BF did emerge in teenhood or early adulthood. Most significantly, there was a long span (5-16years) between surgery (1st, 2nd or 3d operations) and BF appearance.

2 METHODS

Inclusion criteria: Diagnosis of IE, consensually expressed in its definition[8]. In all cases, a convergent deviation started 1-4 months after birth, with clear photographs taken during that period and further on until the date of the first exam. Cases re-examined in the last two years were

chosen. Also selected because development of binocularity occurred at a later stage (≥ age of 9 years) and evolved to an MS stable angle (+/-10$^{\Delta}$ from orthotropia). ***Exclusion criteria:*** Among other excluding usual clauses, patients were also excluded if doubts existed as to the date of the squint first signs. ***Surgical protocol:*** either a unilateral RR or a bimedial recession. Occasionally MR retro-equatorial myopexy was applied. Limbal or fornix incisions were used. Surgery was performed by the same surgeon (FRA) at a private hospital in Lisbon.

Follow up routine: A comprehensive ophthalmological-orthoptic exam was carried out. (1) ***For refraction:*** all were subject to atropine cycloplegia (atropine sulphate 1%, 3 x/ day for 3-5 days). Refraction was periodically rechecked by retinoscopy. Often also by computerized assistance (Sure-Sight AR). (2) ***Visual acuity (VA)*** was assessed (near/distance) by the usual tests dependent upon age; (3) ***Binocularity assessment:*** *For SP,* Bagolini (near and distance), Maddox wing (near), Maddox rod (for distance) were adopted. For *sensory fusion*: Bagolini, Worth 4-dot: (near /distance; macular/foveal); *For motor fusion*: vergences were evaluated with prism bars (near/ distance).Quartiles, interquartile ranges, and median values were analyzed; (4) ***Stereoacuity:*** *For near*, stereoacuity was evaluated using the Randot Preschool Stereoacuity Test, TNO, the Stereo Butterfly Test, Lang-Stereotests I and II, and Frisby. *For distance*, both Randot (3 m.) and the Mentor B-Vat II-SG (6 m.) were adopted. Stereo tests were administered and scored according to commonly established practice and to the manufacturer's instructions; (5) ***Prisms***: Horizontal residual deviations (≤ 10$^{\Delta}$, or vertical (≤ 4-6$^{\Delta}$) following surgery or in-between operations, were corrected adopting ground-in-prisms (GIP), regularly updated. Within monofixation range, GIP were used to *maximally collapse the subjective angle*.

Follow-up at the decisional stage: Length of follow-up was not a matter of concern. When a binocular response was present, therapy was continued, though this decision was dependent upon the parents/patients choice. Treatment was kept until/after adulthood.

Data statistical analysis: the SPSS method of descriptive statistics, (IBM SPSS Statistics, 22, desktop 64-bit version) was adopted for this work.

3 RESULTS

From a total of 45 patients, 22 were male (48.9 %) and 23 female (51.1%). Age of first appointment (AFA) was the date when they were first examined at the clinic. *Mean AFA* was 30.96 ± 17.76 months with a range of 7–72 months. The *mean age for 1st surgery* was 45.93± 20.71 months with a range of 14-84 months. ***Visual acuity:*** Resorting to patching, drug penalization (atropine sulfate) and optical penalization, single or combined, amblyopia, when present, took between 7- 28 months to normalize, with final normal isoacuity (near/distance).

Motor results: Table 1 discloses the number and relative frequency of operations.

Table 1. Results /Surgery: Number, Frequency, and Relative Percentage

Number of operations	Frequency	Percentage
1	29	64.4
2	13	28.9
3	3	6.7
Total	45	100.0

Sensorial results

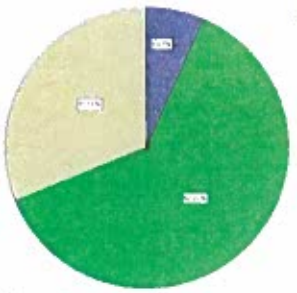

Figure1. Binocularity grade (a) SP Simultaneous Perception (b) Sensory and Motor fusion and (c) Stereopsis

Motor and sensory fusion: On the whole, adding the stereopsis (n=14) and fusion-only (n=28) subsets a total percentage of 93.3% (n=42) exhibited fusion (prism vergences) in real space. Abnormal retinal correspondence (ARC) predominated.

Stereopsis parameters: they are addressed in Table 2.

Emergence of Binocular function: Age of BF first signs varied between 9-46 years with a mean age of 12.31 ± 1.84 years. Mean age of the patients at last appointment (ALA) was 21.60 ± 7.55 with an age range of 11-41 years (Table 3).

Table 2. Results / Stereopsis parameters (")

	Minimum	Maximum	Mean	Standard deviation
Near	200	40	88.57	55.50
Distance	400	60	176	135.20

Table 3. Results/ Age of emergence of BF and age of last appointment (ALA)

	Minimum	Maximum	Mean	Standard deviation
Age of BF emergence (years)	9	16	12.31	1.84
ALA	11	41	21.60	7.55

Time-lags: BF emergence and follow-up: from AFA to the first detection of BF and from AFA to the achievement of a stable monofixation sensory-motor status (Table 4).

Table 4. Emergence of binocular function and time of follow-up (years)

	Minimum	Maximum	Mean	Standard deviation
Follow-up	6	36	16.62	6.68
Time-lag: AFA to BF	5	16	10.31	2.74
Time-lag: AFA to stable BF	10	30	15.49	3.36

* Follow-up period is considered as beginning at the age of the first appointment (AFA) at the clinic

Refraction: With 4 exceptions, hyperopia was low (≤ +3;00D). This finding contrasted with significant astigmatisms (≥ 2;00), noticeable in the large majority of the cohort (95,55%, n =43).

4 DISCUSSION

Stability[19] is arguably the basis for BF, but the latter is, in turn, a guarantor of stability. In consequence, we might submit and hypothesize a putative setting off in motion of a *motor-sensory loop*. This study provides evidence to corroborate it. The fact that most of these patients presented a significant degree of astigmatism acted as a positive spur in prompting a frequent and spontaneous correction of the frame position, thus contributing to a stable isosensory input. The adopted strategy, whereby at the disclosure of the first signs of binocularity, every effort was directed at fine-tuning and correcting motor variables is the core of this medical approach. Remaining vertical/horizontal imbalances were collapsed, namely the horizontal subjective angle to less than 4[Δ], which might act as a fillip in stereo inducement[16]. By laying the foundations for an MS which can occasionally cure[11]and may decompensate[17], though on the whole being still a vector for a stable ocular alignment[11].

Sensitive period for recovery: From the four critical infancy and childhood periods of ontogeny, we are chiefly concerned with this interval of time. It corresponds to the first 5-7 years of life, an age where the visual system still has a higher plasticity and potential for recovery[11]. In this cohort, binocularity resurfaced later (≥ age of 9 years), way above that limit.

In recent years, though, a contrarian bent stressed to a degree, that both the visuomotor system and the brain are plastic [15,19], pliable to adaptation and even capable of creating new neurons cells in adulthood[19]. Examples are found in adult treatment of amblyopia [20,21]and binocularity [22,23]. Those concepts, that of brain and vision as *short-term plasticity systems* and that of *long-term plasticity systems might seem to be opposed.* In the end, however, short-term and long-term plasticity might not be opposing but complementary mechanisms where the latter, comes along as a second phase with some remaining albeit possibly weaker adaptative capacity.

5 CONCLUSION

Summing up, we might highlight that most therapy consensus about IE stresses its poor functional prognosis, the sine qua non urge for very early surgery, preferably before six months of age and the implicit agreement that whenever BF appeared it manifested shortly after surgery.

As opposed to that, this work might express a somewhat better functional prognosis for this condition, along with the message that to achieve sensory results it is worth following IE patients and keep trying for a syndromic monofixational or microtropic condition. In IE, if isomo-

tor (surgery) and isosensory (prisms, off-centered lenses) prerequisites are carefully monitorized BF may emerge even after a gap of several years.
To the best of our knowledge this is the first published work, where, with late operated IE, BF emerged following years of *post-operative treatment.*
Take-home message: (i) Long follow-ups coupled with constant endeavor for isosensorial and isomotor ocular conditions, seem to be subjacent in the delayed functional outcomes;
(ii) Binocular outcomes, emerging a large time-lag (6-36 years) after surgery, are achievable.

REFERENCES

1. Wright KW, Edelman PM, McVey JH, Terry AP, Lin M. High-grade Stereo Acuity Early Surgery for Congenital Esotropia. Arch Ophthalmol. 1994. Jul;112(7):913–9.
2. Birch EE, Stager DR. Long-Term Motor and Sensory Outcomes After Early Surgery for Infantile Esotropia. J Am Assoc Pediatr Ophthalmol Strabismus. 2006 Oct;10(5):409–13.
3. .Wortham E V, Greenwald MJ. Expanded Binocular Peripheral Visual Fields Following Surgery for Esotropia. J Pediatr Ophthalmol Strabismus. 1989;26(3):109–12.
4. Kushner BJ, Morton G V. Postoperative binocularity in adults with longstanding strabismus. Ophthalmology. 1992;99(3):316–9.
5. Ball A, Drummond GT, Pearce WG. Unexpected stereoacuity following surgical correction of long-standing horizontal strabismus. Can J Ophthalmol. 1993 Aug;28(5):217–20.
6. Scott WE, Kutschke PJ, Lee WR. Adult strabismus-20th annual Frank Costenbader Lecture. J Pediatr Ophthalmol Strabismus. 1995;32(6):348–52.
7. Gharabaghi D, Azadeh M. Binocular Vision and Stereopsis Following Delayed Strabismus Surgery. Iran J Ophthalmol. 2006;19(2):46–50.
8. Hoyt C.S, Taylor D. Pediatric Ophthalmology and Strabismus. Fourth Ed. Elsevier Saunders; 2013. 1099 p
9. Birch EE, Stager DR, Berry P, Leffler J. Stereopsis and long-term stability of alignment in esotropia. J AAPOS. 2004;8(2):146–50.
10. Leske DA, Holmes JM, Burkhalter A, Tychsen L, Team AC in FS. The maximum angle of horizontal strabismus consistent with true stereopsis. J Am Assoc Pediatr Ophthalmol Strabismus. 2004 Feb;8(1):28–34.
11..Houston CA, Cleary M, Dutton GN, McFadzean RM. Clinical characteristics of microtropia--is microtropia a fixed phenomenon? Br J Ophthalmol. 1998 Mar;82(3):219–24.
12. Siatkowski RM. The decompensated monofixation syndrome (an American Ophthalmological Society thesis). Trans Am Ophthalmol Soc. 2011 Dec;109:232–50.
13. Arthur BW, Smith JT, Scott WE. Long-term stability of alignment in the monofixation syndrome. J Pediatr Ophthalmol Strabismus. 1989;26(5):224–3
14. Lewis TL, Maurer D. Multiple sensitive periods in human visual development: Evidence from visually deprived children. Dev Psychobiol. 2005 Apr;46(3):163–83.
15.Sur M, Nagakura I, Chen N, Sugihara H. Mechanisms of plasticity in the developing and adult visual cortex. Prog Brain Res. 2013;207:243–54.
16. van Praag H, Schinder AF, Christie BR, Toni N, Palmer TD, Gage FH. Functional neurogenesis in the adult hippocampus. Nature. 2002 Feb 28;415(6875):1030–4.
17. Gage FH. Structural plasticity of the adult brain. Dialogues Clin Neurosci. 2004 Jun;6(2):135–41.
18. Lövdén M, Wenger E, Mårtensson J, Lindenberger U, Bäckman L. Structural brain plasticity in adult learning and development. Neurosci Biobehav Rev. 2013;37:2296–310.
19. Liu H, Li Y, Wang Y, Wang X, An X, Wang S, et al. The distinct role of NR2B subunit in the enhancement of visual plasticity in adulthood. Mol Brain. 2015 Dec 19;8(1):49.
20.Rahi JS, Logan S, Borja MC, Timms C, Russell-Eggitt I, Taylor D, et al. Prediction of improved vision in the amblyopic eye after visual loss in the non-amblyopic eye. Lancet (London, England). 2002 Aug 24;360(9333):621–2.
21. Khan T. Is There a Critical Period for Amblyopia Therapy? Results of a Study on Older Anisometropic Amblyopes. J Clin Diagn Res. 2015;9(8): NC01-4.
22.Reich-d'Almeida F, Reich-d'Almeida I. Some considerations on age-limit in the treatment of childhood squint. In: Transactions VIII International Orthoptic Congress. International Orthoptic Association, 1995 Oct., Kyoto, Japan, Abstract PO 345.
23.Reich-d'Almeida, F. (2003). Uncovering functional results in apparently cosmetic later-age squint patients. International Pediatric Ophthalmology and Strabismus Meeting, 2003 Nov; Anaheim, California, USA.
24. Mets MB, Beauchamp C, Haldi BA. Binocularity following surgical correction of strabismus in adults. J AAPOS. 2004 Oct;8(5):435–8.

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Daniela Eleonora Cioplean

Ophthalmology Clinic OFTAPRO
Bucharest, Romania