



BANGERTER FOILS IN THE POSTOPERATIVE MANAGEMENT OF ESOTROPIA

Galina G. Dimitrova

Children Eye Department, Chair of Ophthalmology, University Alexandrovska Hospital - Sofia, Bulgaria

ABSTRACT

Purpose: To evaluate the application of Bangerter foils in the postoperative management of esotropia

Methods: A retrospective study of 200 patients who underwent bimedial recessions for various forms of alternating/alternated esotropia in the period of 2000-2013. In the cases of residual postoperative angle, tendency of recurrence of strabismus and preferred fixation, Bangerter foil was fixed on the corrective glass of the dominant eye- either on the next day of surgery, or on the 10-th postoperative day and was in use for at least 6 months.

Results: Bangerter foils were applied in 67(35,1%) under corrected patients with a mean residual angle for near $7,01\pm 3,51\Delta$. Mean residual angle in patients without foils was $3,47\pm 4,06\Delta$ ($p<0,001$). Statistically significant factors in patients with filters were amblyopia treatment before surgery ($p<0,001$), anisometropia ($p=0,003$) and type of esotropia (accommodative vs non accommodative ($p<0,001$)).

Within the group without filters there was a significant increase of the residual angle for near on the third ($p<0,001$) and sixth month ($p=0,036$), while within the group with foils angle was not significantly changed ($p=0,325$; $p=0,058$) with time. In the group with foils no cases with relapse of strabismus and amblyopia were recorded and even a decrease of the postoperative angle was clinically observed in some patients.

Conclusion: To our experience Bangerter foils are a reliable tool in the postoperative management of under corrected esotropia.

Key words: Bangerter foils, amblyopia, esotropia, central suppression, fusion

Bangerter foils represent eight semi-transparent filters with graded density, which are originally introduced as an alternative of total occlusion [1] and mainly used as a maintenance partial occlusion in amblyopia treatment [2]. Their role in the primary treatment of mild and moderate amblyopia has recently been confirmed [3, 4, 5]. They have also been applied in the management of intractable and non-surgical diplopia [6, 7, 8], relief of blepharospasmus [9, 10], in many physiological and electrophysiological experiments to simulate a decreased visual acuity [11, 12]. The optical characteristics of the foils have been reconsidered.[18] Patients with strabismic amblyopia have been reported to develop a motor fusion using part-time 0,1 foil [13, 14].

This is a retrospective study to evaluate the role of Bangerter foils in the postoperative management of esotropia.

SUBJECTS AND METHODS:

The report included 200 patients who underwent bimedial recessions for various forms of alternating (96) and alternated (104) esotropia in the period of 2000-2013. There were 78 cases with acquired non-accommodative esotropia (39%); 59-with infantile (29,5%), 43-with partial accommodative (21,5%) and 20- with a high AC/A esotropia (10%). All patients had normal and equal visual acuity or hold fixation of both eyes at the time of surgery. Inclusion criteria were: 1) age under 10; 2) full cycloplegic correction of hyperopia; 3) treated amblyopia; 4) no concomitant vertical deviation or only mild overaction of inferior oblique muscles; 5) no previous surgeries.

Orthoptic examination was performed and recorded before the operation and on the 10-th day, 1-st month, 3-rd month, 6-th month and a year after it- visual acuity, fixation behavior; eye motility; APCT for 33 cm and 5m, Bagolini striated glass test. Target angle was determined by APCT and the maximum motor fusion test, following the quantitative surgical guidelines for bilateral medial rectus recessions [15, 16, 17]. In the cases of residual postoperative angle, tendency for recurrence of strabismus and preferred fixation, Bangerter foil was fixed on the corrective glass of the dominant eye. Usually a filter with PLC, $<0,1$ or $0,1$ density was able to switch fixation to the squinting eye. The filter was put either on the next day of surgery, or on the 10-th postoperative day and was in use fulltime for at least 6 months. 9 patients didn't show up on the control examinations and were excluded from the study. Follow ups recorded visual acuity of both eyes, fixation behavior and preference, residual angle (APCT for 33 cm and 5 m) and Bagolini striated glass test (if possible). Foil application was discontinued when no longer amblyogenic factor (preferred fixation) was observed.

RESULTS:

Bangerter foils were applied in 67 (35,1%) under corrected patients. Only a small number of cases needed the foils for more than 6 months. That is why we studied the effect of Bangerter foils during the period of 6 months. Table 1 shows the number of patients treated with Bangerter foils with time.

Bangerter's foils	3-rd month		6-th month		1 year		More than a year	
	N	%	N	%	N	%	N	%
No	124	64,9	125	65,4	140	88,1	144	94,1
Yes	67	35,1	66	34,6	19	11,9	9	5,9
Total	191	100,0	191	100,0	159	100,0	153	100,0

Table 1. Number of patients treated with Bangerter foils with time

We applied the following methods of statistics: test of Kolmogorov-Smirnov, test of Shapiro-Wilk, t-test (independent samples t-test; paired samples t-test), Wilcoxon signed ranks test. The critical level of significance was p-value < 0,05. SPSS version 13,0 was used.

We compared two groups of patients- these without foils and those with foils. The residual angle was measured by APCT for 33 cm and for 5 m. Some patients were orthotropic for distance and still got a foil for the residual angle for near.

Factors		Patients without foils (n=124)	Patients with foils (n=67)	p-value
AgeMean±SD/		5,56±4,12	5,40±2,31	0,755
Sex (%)	male	55 (44,4)	38 (56,7)	0,103
	female	69 (55,6)	29 (43,3)	
Anisometropia n(%)	no	14 (11,3)	19 (28,4)	0,003
	yes	110 (88,7)	48 (71,6)	
Elevation in Adduction n(%)	no	92 (74,2)	47 (70,1)	0,549
	yes	32 (25,8)	20 (29,9)	
Esotropia	Accommodative no	26 (21,0)	33 (49,3)	<0,001
	Nonaccommodative yes	98 (79,0)	34 (50,7)	
Treatment of Amblyopia n(%)	no	74 (59,2)	17 (25,8)	<0,001
	yes	51 (40,8)	49 (74,2)	

Table 2. Factors for applying Bangerter foils

The mean age of patients with foils and without foils was not significantly different. Table 2 shows that anisometropia (p=0,003), amblyopia treatment before surgery (p<0,001) and accommodative esotropia (p<0,001) were significant factors for applying the foils.

All patients included	Patients without foils (n=124)	Patients with foils(n=67)	p-value
Residual angle 1-10 day (APCT 33cm) /Mean±SD/	3,47±4,06	7,01±3,51	<0,001
Residual angle 3-rd month (APCT 33cm) /Mean±SD/	5,02±5,74	8,15±3,75	<0,001
Residual angle 6-th month (APCT 33cm) /Mean±SD/	5,48±6,78	7,77±4,11	<0,001

Table 3. Residual angle in the two groups-without foils and with foils with time

Table 3 shows the residual angle in the two groups-without foils and with foils with time. The mean initial postoperative residual angle for 33 cm in the group with foils was 7,01±3,51 and was significantly bigger than in the group without foils (3,47±4,06; p<0,001). The residual angle, measured on the 1-10th day for 5m (when all patients were included) did not show significant difference in the two groups (2,85±3,96vs3,85±4,14; p=0,075).

On the 3-rd and 6-th month, the residual angle, measured by APCT for 33 cm was still significantly bigger in the group with foils than in the group without foils.

Comparison: residual angle (APCT 33 cm)	Patients without foils (n=124)		Patients with foils (n=67)	
	Mean±SD	p	Mean±SD	p
1-10 day	3,47±4,06	<0,001	7,01±3,51	0,065
3-rd month	5,02±5,74		8,15±3,75	
1-10 day	3,47±4,06	<0,001	7,01±3,51	0,325
6-th month	5,48±6,78		7,77±4,11	
3-rd month	5,02±5,74	0,036	8,15±3,75	0,058
6-th month	5,48±6,78		7,77±4,11	

Table 4. Comparison of the residual angle for 33 cm within the two groups

Table 4 compares the residual angle for 33 cm with time within the group without foils and within the group with foils. There was a significant increase of the deviation with time in the group without foils and a stable deviation in the group with foils on the third and sixth month.

If patients with orthotropia for 5m were excluded and only those with residual angle for 5 m were considered, a significant bigger residual angle in the group with foils (p=0,041) was found out at the beginning of foil application, while on the sixth month the bigger residual angle was in the group without foils (p=0,046), as shown on table 5.

Patients with orthotropia for 5m excluded	Patients without foils	Patients with foils	p-value
Residual angle 1-10 day (APCT 5m) Mean±SD/	(n=52) 6,81±3,22	(n=34) 7,59±2,24	0,041
Residual angle 3-rd month (APCT 5m) Mean±SD/	(n=58) 9,36±5,08	(n=45) 8,09±3,60	0,311
Residual angle 6-th month (APCT 5m) Mean±SD/	(n=59) 10,31±7,43	(n=45) 7,62±4,02	0,046

Table 5: Residual angle for 5m, when orthotropic patients are excluded

In some patients we clinically observed a decrease of the residual postoperative angle after continuous penalization of the dominant eye with Bangerter foil. (fig.1, 2, 3)

Fig.1 A patient with alternated esotropia with and without glasses before surgery



Fig.2 A residual postoperative angle in the right eye and a <0,1 Bangerter foil on the glass in front of the left eye (with preferred fixation), switching the fixation to the right (squinting) eye



Fig.3 The decrease of the postoperative angle on the 6-th and 9-th month after surgery



DISCUSSION:

We started applying the filters in the cases of postoperative undercorrection to prevent postoperative amblyopia. We followed the Lang's approach of strabismic amblyopia treatment using Bangerter foils. Our choice of this type of partial occlusion was dictated by the fact, that part-time occlusion removes the suppression scotoma only for 2-3 hours, while roughly disrupting the kind of binocular vision we have just established by surgery. On the other side, semi-transparent filters, even the dense ones, allow peripheral interaction between the two eyes while full time remove the suppression. We didn't use a predetermined foil density, but rather fixed this foil, which penalized the dominant eye so that a switch of fixation to the squinting eye was achieved. Lang [2] had ordered a production of light perception foil, as he observed that sometimes $<0,1$ filter was not sufficient to provoke a switch of fixation. May be it is because contrast sensitivity was not influenced through less transparent filters and is considerably decreased after $0,1$ foil as it was later found out reconsidering the optical characteristics of the foils. [18]

Lang used the densest filter for six months and then tapered with less transparent one every 3 months. He was not concerned about the binocular neurons function using partial occlusion without interruption, for graded filters provide for continuously elimination of the amblyogenic suppression under binocular interaction. By using them in a tapering manner, he insured a more central binocular interaction with each more transparent foil.

In our group with foils we started with density PLC, $<0,1$ or $0,1$, because more transparent foils couldn't switch fixation in spite of the normal and equal visual acuity of both eyes. Patients with anisometropia, amblyopia treatment before surgery and esotropia with accommodative component more often demonstrated unilateral preferred fixation and residual angle needed foil application. In patients with abnormal retinal correspondence the eyes strive for reestablishing the preoperative situation and tend to increase the postoperative residual angle. In such patients we penalized the dominant eye speculating than by removing the suppression scotoma in the squinting eye and force it to fixate, we stop it from regaining the angle. To fulfill our goal, we had to be sure the squinting eye not only took, but also hold the fixation and the dominant eye did not still fixate through the filter. It seemed six months was time enough for the brain to get used to the smaller postoperative deviation. We did not taper the foil density but discontinued the foil applica-

tion when amblyogenic factor existed no longer and preferred fixation was not observed any more. Our results showed that this approach did not allow the squinting eye develop postoperative amblyopia and increase the residual angle. Even in some patients a decrease in the postoperative angle was clinically observed.

Abrams et al. [13,14] reported the development of motor fusion when patients with a history of strabismic amblyopia were treated part-time (3-4 hours) with $0,1$ Bangerter foil. Their study was designed to follow the motor fusion status in patients with $\leq 20\Delta$ strabismic amblyopia and they had chosen $0,1$ foil on purpose. Reducing the visual acuity of the penalized eye to $20/200$, a suppression of the foveal information and stimulation of the parafoveal region of the penalized eye was achieved - a region felt to be important for providing information that drives motor fusion. Motor fusion was evaluated with a 10Δ base out test for prism vergence.

Of the 46 patients in their study, 28 (61%) developed motor fusion on the 10Δ base out test after a mean of $6,6 \pm 5,9$ months. The authors reported a significant decrease in the mean horizontal deviation associated with the development of motor fusion ($p=0,01$). They suggested that the improved binocular interaction between the parafoveal regions of the two eyes may have helped motor fusion observed in their study. Once motor fusion developed, it persisted even Bangerter foil was discontinued. Although the general believe that motor fusion developed during the early formative period, this study reported of majority of patients at a bigger age who improved steadily their motor fusion status using $0,1$ Bangerter foil.

In our group of patients from 200 operated for esotropia, 67 were with a residual angle (35%) and only 12 (6%) underwent a second surgery for the horizontal deviation, due to the postoperative application of Bangerter foils. Weakness of our report is that it is not specially planned for a study. It shows our retrospective statistical and clinical observations proven with time.

CONCLUSION:

To our experience Bangerter foils are a reliable tool in the postoperative management of esotropia to stop the relapse of strabismus and postoperative amblyopia. This application of the foils is not popular neither in the literature nor in the practice and needs further analysis in a prospective and specially designed study.

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Address for correspondence:

Galina Dimitrova,
Chair of Ophthalmology, Children's Eye department, University Alexandrovska Hospital - Sofia;
1, St Georgi Sofiiski Blvd., 1431 Sofia, Bulgaria;
E-mail: gadim62@yahoo.com