RESEARCH ARTICLE

AN ALTERNATIVE-FORMULA FOR RECESSING-RESECTING MUSCLES IN CORRECTION OF EXOTROPIC AND ESOTROPIC STRABISMUS

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ARTICLE INFO	ABSTRACT
	There are many ways to measure the angle of strabismus and many methods to calculate the amount of muscle recess-resect in a pair of opposing muscles. We used the Hirschberg method for measuring the kappa angle and we describe an alternate-formula which is simple for calculating the amount of muscle to recess-resect for the surgical correction of strabismus in 70 patients with either esotropia or exotropia. Some surgical techniques and results are reported herein after ten years follow-up.

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INTRODUCTION

In normal vision, the image of a point of fixation will fall on the fovea of each eye. This is the visual axis. In the presence of strabismus, a condition of ocular deviation, the image falls on the fovea of only one eye. The amount of deviation is determined by the angle formed by the visual axis of the two eyes. In normal eyes, the Kappa angle is measured between the visual axis and an axis perpendicular to the cornea through the center of the pupil or pupillary axis, approximately 5 degrees (Fig. 1). (Gharaee *et al*. *Angle Kappa Measurements*) Broadly speaking, strabismus is caused by an unequal pulling of one or more of the muscles that move the eyes (nonparalytic strabismus), or by paralysis of one or more of these eye muscles (paralytic or paretic strabismus). In strabismus, the deviation may be inward (esotropia), outward (exotropia), upward (hypertropia) or downward (hypotropia). Strabismus may also be intermittent, related to the distance of the point of fixation, secondary to psychological stress, or associated with A or V syndrome. In 'A' esotropia, the deviation is greater in eyes pointing up than in eyes pointing down; in 'A' exotropia, the deviation is greater in eyes pointing down than in eyes

pointing up. Conversely, in 'V' esotropia, the deviation is greater in eyes pointing down than in eyes pointing up; and in 'V' exotropia, the deviation is greater in eyes pointing up than in eyes pointing down. (Gibson *et al*. *Anomalies of binocular position, visual perception and ocular motility in strabismus*; Vaughan *et al*. General Ophthalmology) In Vietnam, strabismus is present in 0.53% of the population, and is responsible for 2% of all cases of blindness (Ngo Nhu Hoa. *Some consideration on the epidemiology of cataract in Hochiminh City*) For the purposes of treatment, strabismus is classified into two categories: paralytic and functional. Before surgical intervention is considered, correction of strabismus should be attempted by: 1) the use of spectacles in patients with refractive errors (myopia in exotropic patients, hyperopia in esotropic patients); and 2) total or partial occlusion of the deviated eye in children aged 7 to 14 years. Strabismus may cause lack of binocular vision, loss of useful vision, psychologic manifestations, and social and economic problems. For these reasons a child with strabismus should be examined as soon as possible. In many cases, treatment can be initiated in infancy (Sugar HS. *The extrinsic of orthoptic instruction*; Burian HM. *Syllabus of orthoptic instruction*; Saraux *et al*. Ophthalmologica) There are many ways to measure the angle of strabismus and many methods to calculate the amount of muscle recess-resect in a pair of opposing muscles. We used the Hirschberg method for measuring the kappa angle and we propose a simple formula for calculating the amount of muscle

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to recess-resect for the surgical correction of strabismus in patients with either esotropia or exotropia (Miller S. Clinical Ophthalmology; Von Noordon G. *Main causes of failure in strabism surgery*)
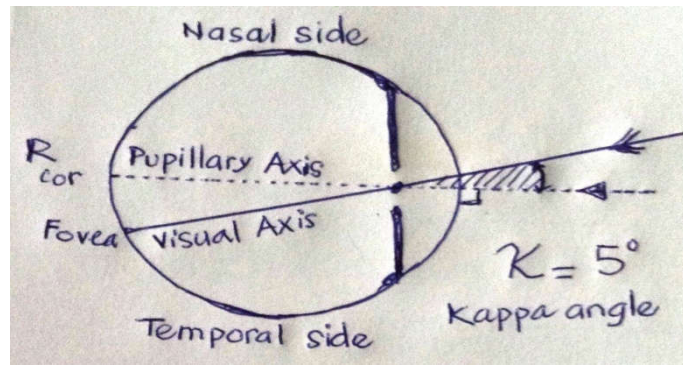

Figure 1. Kappa angle

MATERIALS AND METHODS

Design: Clinical trial on consecutive patients. Self-control: Pre-surgery and post –surgery.

Patients: All patients signed an agreement for his or her surgery after ophthalmologist' diagnosis and advice. In case of the children are signed by their father or mother. Surgery was done with local anesthesia and follow-up by one ophthalmologist at the private patient office from 1985 to 2000. Hypertropic and hypotropic strabismus patients and those with an A or V syndrome are excluded (Duong Dieu, *Strabismus and surgical correction*)

For diagnosis: We used the Hirschberg method to measure the kappa angle. Normally, when light strikes the cornea, a reflex occurs on the center of the cornea of each eye. In cases of strabismus, the corneal reflex falls at some other position than at the center and thus the related deviation can be assessed in degrees of arc as in the following examples of corneal reflex position: central reflex = 0 degree; reflex at the pupillary margin = 15 degrees; half-way to the limbus reflex = 30 degrees; at the limbus reflex = 45 degrees; and 1 mm beyond the limbus = 60 degrees (Miller S. Clinical Ophthalmology)

For surgical treatment: The goals of our surgery were: 1) to change the position of the eyeball in order to alter the alignment of the eye as soon as possible; 2) to reduce (weaken, lengthen, recess) or to enhance (shorten, strengthen, advance, resect) the action of individual muscles; and 3) to create and maintain normal rotation of the eyeball and concomitance (Sugar HS. *The extrinsic of orthoptic instruction;* Burian HM. *Syllabus of orthoptic instruction;* Saraux H, *et al.* Ophthalmologica)

+ A Proposed Alternative Formula:

Theoretically, the circumference of the eyeball is 72 mm; therefore, a displacement of 1 mm should move the optic axis 5 degrees (360/72). Lancaster points out that 1 mm of displacement on the sclera corresponds to 4° of rotation, but at the center of the cornea the correspondence is 5 degrees. Wiener and Alvis reported that 1 mm of recession on both corrected muscles resulted in 10 degrees of correction. Jameson has reported that 1 mm of recession results in 5 degrees of

correction if the recession was performed on the internal rectus muscle and 2 degrees of correction if the recession was performed on the internal rectus muscle (Gibson GG, Harley RD. *Anomalies of binocular position, visual perception and ocular motility in strabismus*)

The following **Kunz Formula:**

k = s1 x [m1/ (m2+m2)] + s2 x [m2/ (m1=m2)]

If s1 =   s2
k =   s, where
k =   the change in position of the globe (^{o});
s1, s2 = the amount of displacement of the muscles (mm);
m1, m2 = muscle and opposing muscle.

For Kunz's table of surgical resection and recession of muscle with details in Table 1.

Table 1. Kunz's table of surgical resection and recession of muscle

Deviation (degree)	Resection (mm)	Recession (mm)
10 to 11	3	4
12 to 13	3.5	4.5
14 to 16	4	5
17 to 18	4.5	5.5
19 to 20	5	6
22 to 23	5.5	6.5
24 to 26	6	7
27 to 28	6.5	7.5
29 to 31	7	8
32 to 33	7.5	8.5
34 to 36	8	9
37 to 38	8.5	9.5
39 to 40	9	10

Proposed Alternative Formula:

As demonstrated in Figure 2, we propose a simple formula as follows:

d1 = d2 = ½ x D/2= D/4

d1 = d2: resect = recess muscle (mm), where
D = Deviation degree calculated by the Hirschberg method:
Reflex at the pupillary margin = 15 degrees, d1=d215/4=3, 75 mm.
Reflex at the half-way to the limbus = 30 degrees, d1=d2=30/4=7, 50mm;
Reflex at the limbus = 45 degrees, d1=d2=45/4=11, 25mm. (See Table 2)

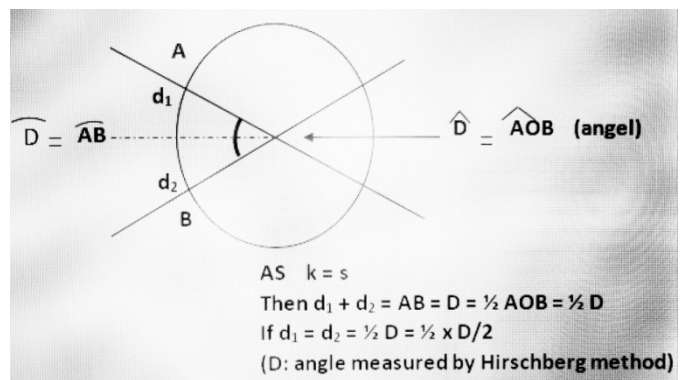**Fig. 2. Proposed alternative formula**

Table 2. Comparison of author's method with Kunz's table of surgical resection and recession of muscle

Deviation	Our method		Kunz's method	
(degrees)	resect (mm)	recess (mm)	resect (mm)	recess (mm)
15	3.75	3.75	4	5
20	5	5	5	6
25	6.5	6.5	6	7
30	7.5	7.5	7	8
35	8.75	8.75	8	9
40	10	10	9	10

+ Some surgical techniques in recessing-resecting of muscles

For resection we used the Lancaster procedure: free and expose the muscle as much as possible by using a strabismus book, tie the suture over the muscle, and then cut the excess muscle. For recession we used the Jameson procedure: expose the muscle, tie a chromic single-armed suture at each edge of the tendon near its scleral insertion, cut the muscle at the insertion and pass the suture through a superficial layer of sclera. (Fig.3)
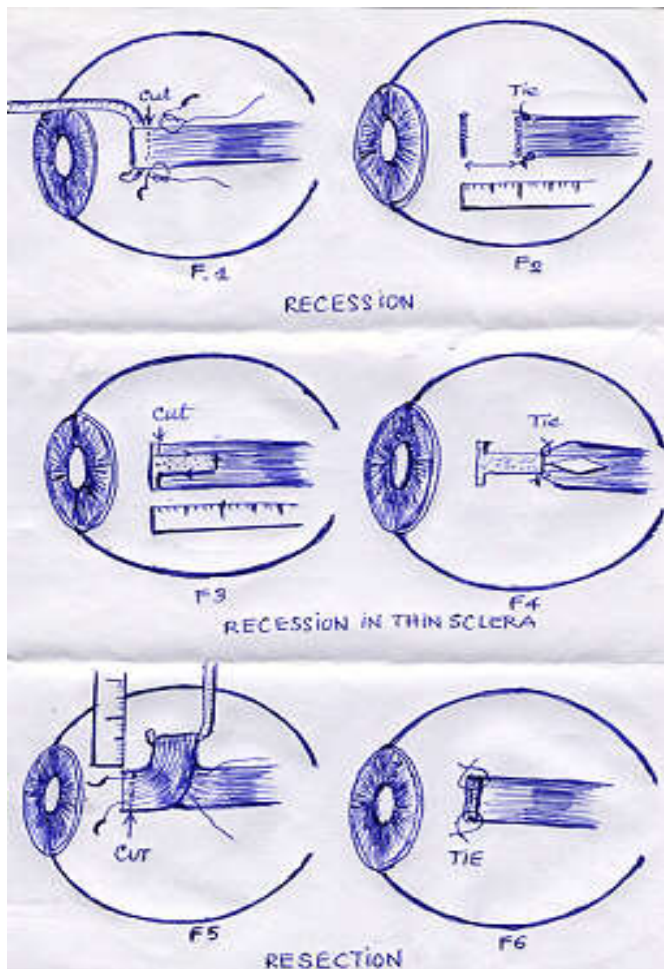

Figure 3. Techniques of surgery in muscle recession-resection

We operated on the agonist muscle causing the deviation before the antagonist muscle. For example, in the esotropic cases, we started by recessing the medial rectus muscle and then resected the lateral rectus muscle. In the exotropic cases, the recession of the lateral rectus muscle was performed prior to the resection of the medial rectus muscle. In the esotropic cases, because the medial rectus muscle is stronger than the lateral rectus muscle, we operated to achieve undercorrection and in the exotropic cases, we operated to achieve exact

correction. If the deviation was greater than 40° to 45° in both eyes, surgery was performed to accomplish both the correction of deviation and the width of the eyelid in both eyes (Miller S. *Clinical Ophthalmology; Von Noordon G. Main causes of failure in strabism surgery*)

Top: Muscle recession.

Middle: Muscle recession in case of thin sclera or children.

Bottom: Muscle resection.

RESULTS AND DISCUSSION

Table 3 shows 70 patients according to group of deviation by Kappa (Hirschberg method). Table 4 shows the family history. Tables 5 and 6 are the age and type of onset. Tables 7 and 8 report the sex, age, and type of strabismus distribution.

Figure 4. Left= Preoperation: Reflex at the near limbus-deviation calculated by the Hirschberg method= Esotropia 40 degrees- Operation: recession = resection =40/4=10mm. Right=Post operation: 12 months. Central reflex = 0 degree

Figure 5. Left= Preoperation: Exotropia 36 degrees- Deviation calculated by the Hirschberg method. Operation: recession = resection=36/4= 9 mm. Right=Post operation: 6 months

Table 3. Kappa (Hirschberg method) and grouping of patients by deviation

Group and deviation	Exotropia (number)	Esotropia (number)
I = 10 to 15°	7	9
II = 26 to 35°	14	21
III = 36 to 50°	8	11
IV > 50°	0	0
Total patients	**29**	**41**

Table 4. Family history of strabismus

	Father + mother with strabismus	Father or mother with strabismus	No father or mother with strabismus
Patients	3	9	58
Percentage	4.28	12.85	82.85
Note: In the 12 patients with inherited strabismus there were 8 esotropes and 4 exotropes. Autosomal dominant inheritance is common.		

Table 5. Age of onset of strabismus

Age (years)	2-6	7-14	>15	Unknown
Patients	45	13	7	5
Percentage	64.28	18.57	10	7.14
Note: The earlier the onset, the worse the prognosis for fusion.				

Table 6. Type of onset of strabism

	Fever	**Trauma**	**Unknown**
Patients	12	5	53
Percentage	17.14%	7.14%	75.71%

Table 7. Sex and type of strabismus distribution

MALE:	**18 (25.71%)**	**FEMALE: 52 (74.28%)**	
Exotropia	Esotropia	Exotropia	Esotropia
5 (7.14%)	13 (18.57%)	24 (34.28%)	28 (40%)

Table 8. Age and type of strabismus distribution

< 7 yr.		7 to 14 yr.		15 to 25 yr.		26 to 45 yr.	
2 cases	2.8%	16 cases	22.8%	35 cases	50%	17 cases	24.3%
Exo	Eso		Eso		Eso		Eso
0	2	Exo	11	Exo	19	Exo	9
0%	2.8%	5	15.7%	16	27.1%	8	12.8%
		7.14%		22.8%		11.4%	
Note: There is an insignificant difference between exotropia and esotropia among the three age groups ($x2 = 1.14; p > 0.05$):							
< 15 years old: 18 patients = 5 exo + 13 eso							
15-25 yr.: 35 patients = 16 exo + 19 eso							
26-45 yr.: 17 patients = 8 exo + 9 eso							
There is a significant difference between the age groups < 15 yr. (18 patients) and > 15 yr. (52 patients). The age of operation is concentrated in the 15 to 25 yr. group.							
The youngest patient was 5 years old, the oldest, 45 years old.							

At the third postoperative month, in group III (with 30° to 50° deviation) of patients with exotropia, 8 were operated and 1 was re-operated; of patients with esotropia, 11 were operated and 1 was re-operated. Two of the re-operated patients in group III had an angle of deviation > 40°. In the first operation, one eye (2 muscles) was operated on and the fellow eye had to be operated on in the second operation in order to correct hypocorrection. Two of the 70 patients (2.85%) required a second operation. There were no cases of hypercorrection. The average postoperative follow-up was 6 months (50 patients, 71.42%). The longest postoperative follow-up period was 10 years (2patients). There was no postoperative diplopia (Duong Dieu, *Strabismus and surgical correction*)

Conclusion

Effect of surgery on the extraocular muscles depend on many factors, including the age at onset of the squint, the age of patient at the time of surgery, the stability of the angle of squint, the size of the angle of squint, and the technique used. In most cases, surgical treatment should be considered only as a supplement to optical and orthoptic treatment. We established our diagnoses based on the Hirschberg method and we have used our simple formula which was described above for calculating recessing-resecting muscles with some satisfying results.

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