HORIZONTAL SQUINT SURGERY*† THE MATHEMATICAL APPROACH

BY

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STANDARDIZATION of the surgical treatment of strabismus has long been the ambition of surgeons. Even for the most experienced the number of millimetres of recession or resection to perform is always a difficult decision. Because of individual variation in response to similar surgical procedures, Cooper (1961) believed it difficult to predict the result. Knapp (1958) considered accurate estimation impracticable, and Scobee (1952) and Stallard (1965) regarded it as impossible.

The general principles of muscle surgery are discussed often enough, but precise detail regarding the amount of muscle to move or remove is frequently omitted and the decision is left to the surgeon's skill and experience in each individual case. Lyle (1950), Scobee (1952), Castanera Pueyo (1958), and Cooper (1961), who have all described the conditions that may influence the result of the operation, vary considerably in their estimation of the relationship between the amount of recession or resection and the degree of correction of squint. Lyle (1950) stated that a 5 mm. recession of the medial rectus produced an average final reduction of between 7° and 12° , and that the average effect of resection of the lateral rectus "is to reduce the angle of deviation by about 10° ", adding that "it is usually combined with either recession or tenotomy of the medial rectus, and then the combined effect is about 25 per cent. greater than that of each operation separately".

Castanera Pueyo (1958) stated that for each millimetre of recession of the medial rectus there should be a correction of 3° , but for each millimetre of resection of the lateral rectus only 1° or even less. Stallard (1965) held that roughly 1 mm. of recession of the medial rectus corrected about 4° of strabismus and 1 mm. of adjustment to the lateral rectus about 2° .

Among the most interesting attempts to standardize the surgical treatment of horizontal strabismus, reference must be made to the work of Urist (1951). His surgery, as he states, "is theoretically based on the concept that the position of the eyes is determined by a state of balance between convergence and divergence innervations", and his operative procedure is predetermined by the amount of deviation present for distance vision and upward gaze compared with that of near vision and downward gaze.

Present Investigations

This paper, which is a sequel to work done by one of us (Matos Sousa, 1962, 1963), presents the results of surgery of convergent strabismus using a mathematical formula to estimate the amount of resection of the lateral rectus. This formula based on the accom-

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modative component of the deviation was established by a long series of experiments. It was first decided to perform a 5 mm. recession of the medial rectus in all cases except in special circumstances. It soon became apparent that similar lateral rectus resections gave different results in cases which had presented with equal deviations after the correction of refractive error. This led us to consider the importance of the accommodative component, as it was observed that the stronger it was the less was the corrective effect of surgery. Furthermore the accommodative component was seen to be related to the amount of lateral rectus to be resected, and the following mathematical formula was devised:

$$R = 1 + \frac{2A - B}{5}$$

where R = Resection in millimetres to be performed on the lateral rectus.

A = Angle of strabismus in degrees measured without the correcting glasses.

B = Angle of strabismus in degrees measured with the correcting glasses of hypermetropia (in cases of emmetropia A and B are equal).

Examples of Calculations

Angle of Deviation without glasses with glasses		Calculation	Resection (mm.)
+12°	+10°	$R = 1 + \frac{14}{5} = 3.8$	4
+25°	+15°	$R = 1 + \frac{35}{5} = 8$	8
+25°	+18°	$R = 1 + \frac{32}{5} = 7.4$	7
+28° to +32°	+22° to +26°	$\left\{ \begin{array}{l} R = 1 + \frac{34}{5} = 7.8 \\ R = 1 + \frac{38}{5} = 8.6 \end{array} \right.$	8
+21° to +22°	+15° to 18°	$\left\{ \begin{array}{l} R = 1 + \frac{27}{5} = 6.4 \\ R = 1 + \frac{26}{5} = 6.2 \end{array} \right.$	6

This formula is applicable only in non-myopic eyes with horizontal convergent strabismus which cannot be corrected by recession of the medial rectus alone. The maximum resection should not be more than 10 mm. in children, but in adults up to 14 mm. of muscle may be removed. This formula has, therefore, a wide range of application as convergent strabismus in cases of myopia is uncommon. Attention should, however, be called to two exceptions:

- (1) When the medial rectus is stronger and has more tonicity than usual, the resection of the lateral rectus should be more extensive than that estimated by the formula (Matos Sousa, 1962).
- (2) When the lateral rectus is either exceptionally strong or very weak it is necessary to add or subtract 1 or 2 mm. to the R obtained by the formula.

Certain important technical and surgical details must also be borne in mind:

- (1) From the total refraction under cycloplegia, 1/1.5 dioptres must be subtracted from the hypermetropia, after which the angle of squint with glasses is estimated.
- (2) The angles should be measured very carefully and accurately.
- (3) When the recession of the medial rectus is performed, the sutures on the tendon should be 2 to 3 mm. behind its anatomical insertion.
- (4) The resection of the lateral rectus should be performed after careful dissection of the muscle, which should extend beyond the portion to be removed.
- (5) Prince's forceps should be placed at a distance of *R*-3 mm. from the end of the muscle. These 3 mm. correspond to the sum of the width of the teeth of the forceps (2 mm.) and the space occupied by the suture (1 mm.).
- (6) The two U-sutures used for replacing the lateral rectus should be passed through the sclera at the muscle insertion and then through the muscle as close as possible to the forceps.

Results

The results obtained have been excellent, irrespective of the surgeon's experience. In 308 cases (210 for functional recovery and 98 for cosmetic reasons) operated upon according to the stated formula, the results were as follows:

<i>No. of Cases</i>	<i>Residual Angle (°)</i>	<i>Percentage</i>
260	0° to +5°	84.42
18	+6°	5.84
4	+7°	1.30
4	+8°	1.30
8	+10°	2.60
1	+12°	0.32
4	+15°	1.30
2	-1°	0.65
2	-3°	0.65
2	-4°	0.65
3	-5°	0.97

The results were considered satisfactory if the post-operative angle was between 0° and +6°, and only thirty cases failed to reach this standard (9.7 per cent.). Of these thirty, nine have been cured by orthoptic methods and only four cases needed re-operation. The remaining seventeen cases had been treated for cosmetic reasons.

These statistics do not include cases operated on by colleagues who have used the technique both in our department and in their own clinics, but we learn that their results have been, in general, satisfactory.

Summary

308 cases of strabismus were operated on according to an original mathematical formula for estimating the exact amount of muscle recession and resection. This formula is based on the accommodative component of the deviation and is applicable only in non-myopic eyes with horizontal convergent strabismus which cannot be corrected by recession of the medial rectus alone. The results obtained have been excellent.

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