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FORMULAS FOR THE GRADUATION OF THE EFFECTS OF CONVERGENT SQUINT OPERATIONS

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He who does not wish to endanger his good reputation as a physician has not for some time placed value in keeping a distance from mathematics. Earlier, understanding of art or love for music promoted one's personal prestige; chemistry and physics were useful auxiliary sciences with which one should have little contact, and statistics were regarded as a purchasable lady of the street. This lets itself be clearly applied when approaching the question of whether the success of a squint operation can be calculated. The more prestige and true experience a squint surgeon of the previous generation had, the more he rejected mathematical methods for the determination of the necessary extent of a squint operation. To operate was an art, and the extent of surgery was determined by artistic intuition.

Quite naturally, however, there were "outsiders". The problem ever again challenged ophthalmologists oriented in the natural sciences. Subsequently, solutions on a basis of geometry were sought. They proposed that, after V. PFLUGK, in eye globes of average size, recession and resection each of 1 mm. on both horizontal motor muscles resulted in a change of the squint angle of 5 degrees; that is, when each is 2 mm., then the change is 10 degrees.

In an interesting article from the year 1949, KUNZ showed that this geometric model is applicable when the following two conditions are met:

1) One must achieve equally strong effects on both horizontal motor muscles, and

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2) For operative-technical reasons, the effect of resection is actually 1 mm. less than that measured, and, of recession, 2 mm. less. Por example, to accomplish a turning of the globe through 20 degrees, one must perform a resection of 5 mm. combined with a recession of 6 mm. Both together achieve a change of the muscle attachment or of its length of 4 mm., and this, in turn, results in a change of the squint angle of 4 x 5 = 20 degrees. Mathematically, this relationship of KUNZ can be expressed as follows:

$$DS = 2.5\ (M—1) + 2.5\ (R—2) \text{ where}$$

DS = Difference in squint angle (in degrees)

M = Extent of myectomy in mm.

R = Extent of recession in mm.

(M—1) and (R—2) must be equal.

Correspondingly formulated, the formula of PFLUGK can be so expressed:

$$DS = 2.5M + 2.5R;\ R = M$$

As we can see, this leads to excessively high values for DS. The modification of KUNZ, on the other hand, comes quite close to the results produced empirically.

Today, many ophthalmologists know that such problems may be solved with the aid of biometrical methods. The study of the question involved in the relation between the intensity of the operative procedures and the change of the squint angle is a classical example for the use of biometry. It is astonishing that it has until now been so sparingly used for that purpose. We know that:

1) Similar extents of squint operation can in different patients lead to different results with respect to the change of squint angle, and

2) Similar extents of squint operation can with different surgeons lead to different results, also with respect to the change of squint angle.

From the above, it follows that, in addition to geometry, other factors influence the result of a squint operation. Through the use of probability analysis, one can establish that:

1) If a squint operation of a particular extent leads to and average change in the squint angle, and how great are the variations about the mean value, and

2) If the results of different surgeons performing operations of a similar extent are comparable.

The presuppositions necessary for success in such a biometric study are:

1) Exact experimental planing to which belongs the standardization of measuring methods, the fixing of examination dates, and exact regulation of the operative procedure.

2) Data gathering with the documentation of results and of influencing factors, and

3) Data processing with error computation.

Such a study was performed for the Twentieth International Congress of Ophthalmology in 1966. The compilation and handling of the data was assumed by Professor LINDER of Geneva. One surgeon from each of six eye hospitals participated. Professor LINDER established that the results of 5 of the 6 surgeons were comparable with one another. For these, the following formula held true:

$$DS = 5R + 2M - 12 \text{ where.}$$

DS = Difference in squint angle (in degrees).

R = Extent of recession of the M. rect. int. in mm.

M = Extent of the resection of the M. rect. ext. in mm.

This formula shall be referred to in the discussion as LINDER/one. For the sixth surgeon another formula (LINDER/two) was calculated:

$$DS = 5R + 2M - 22$$

Hence he achieved with a similar extent of surgery an average of 10 degrees less change in the squint angle as did the other five surgeons. The reason for that remained unclear. His results with respect to achieving parallel alignment of the eyes were especially good.

Table 1 shows the variation of the operative results from the expected value as calculated from the formula. As could be expected, there is considerable deviation, but the distribution is normal. The subsequent step consisted of determining whether the results of squint operations by a single clinic's staff not subject to strict operative guidelines could be comparable. For this group of surgeons we established the formula:

$$DS = 2.7R + 1.1M \text{ (figure 1).}$$

> - 9	-9 bis -6	-6 bis -3	-3 bis +3	+3 bis +6	+6 bis +9	> +9
2	6	10	42	15	5	3

TABLE 1

Upper line: Aberrations from LINDER (1) in 83 cases of combined squint operations. 5 operators. Lower line: Number of cases.

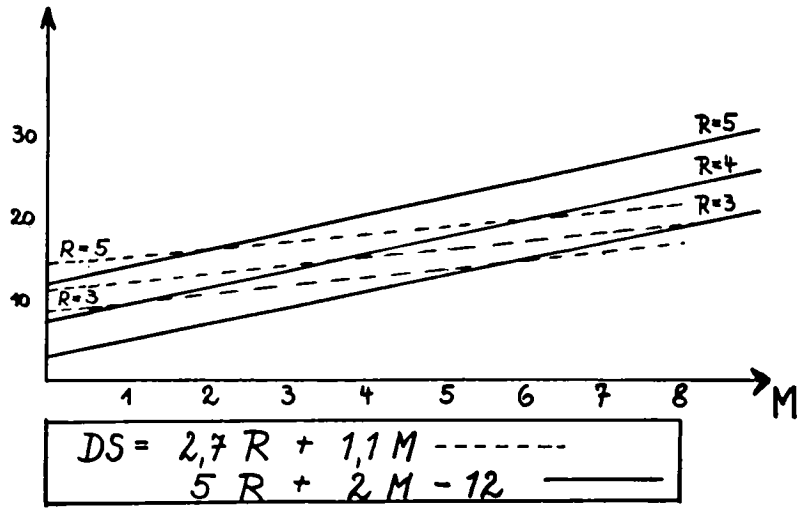


FIGURE 1

Comparison between LINDER (1) and the formula for Bonn University Eye Clinic assistants, calculated by HACKER.

Hence, the effect of the operations was considerably less than that of the first group, especially following surgery of greater extent. However, it is striking that the relationship, R: M, is 5: 2 as is also the case in LINDER's formula.

In recent years we have strived to compare the results of these biometrical studies with those obtained when applying surgery of an empirically-

recommended extent. In doing so, it occurred to us that the empirical recommendations, just as our statistical calculations do, allow a linear relation to be recognized between the extent of operation and the success with respect to the change of the squint angle. This holds true, for example, for the changes of the squint angle in particular proportion to internus-recession employing increased myectomy, following the data of KUNZ, AWETISOFF and KAUFMANN. The latter alludes to me asurements before and after 360 combined recession-resection operations (figure 2). The relationships of SUGAR, without sharp deviation from the expected values of the other authors, and of SARRAUX follow a non-linear course. These two non-linear

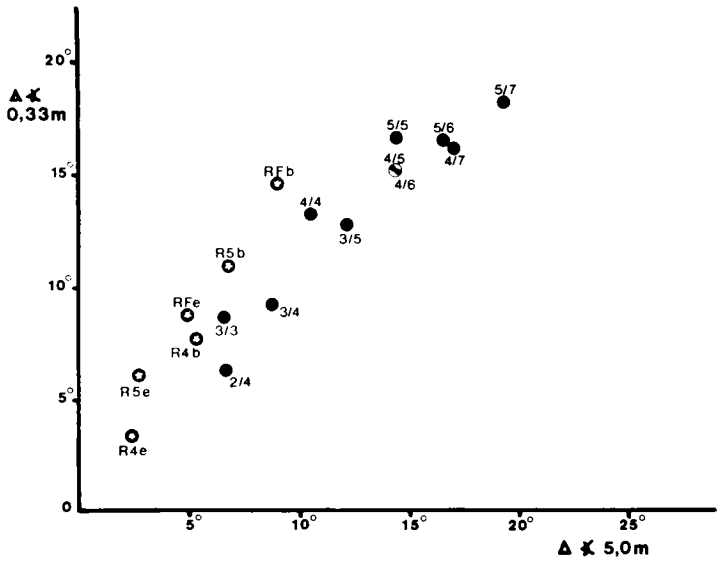


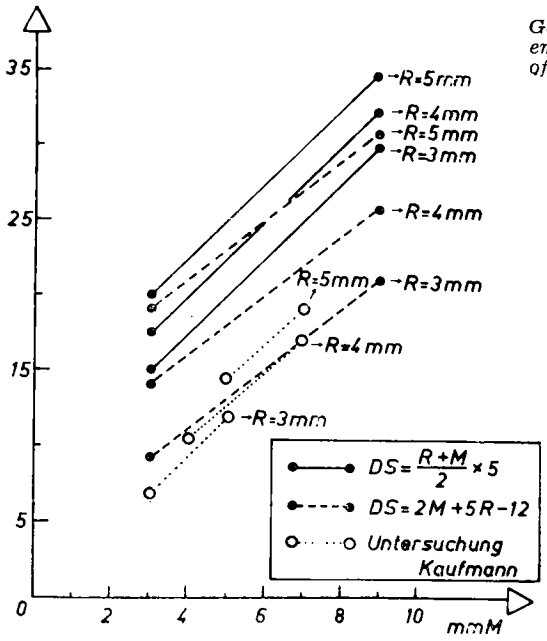
FIGURE 2

Expectation values after KAUFMANN for combined squint operations. Abscissa: Squint angle for distance 5 m. Ordinate: Squint angle for near-vision (0,33 m.). First number = resection. Second number = resection.

relationships are very clearly divergent (figure 3). Practically all empirically-derived expected values lie between the two relationships calculated by LINDER for the surgeons participating in his series. Indeed the difference between them amounts to 10 degrees, which seems to be considerable. The

FIGURE 3

Geometrical, biometrical and empirical data for the effect of combined squint operations. Recession = 4 mm.



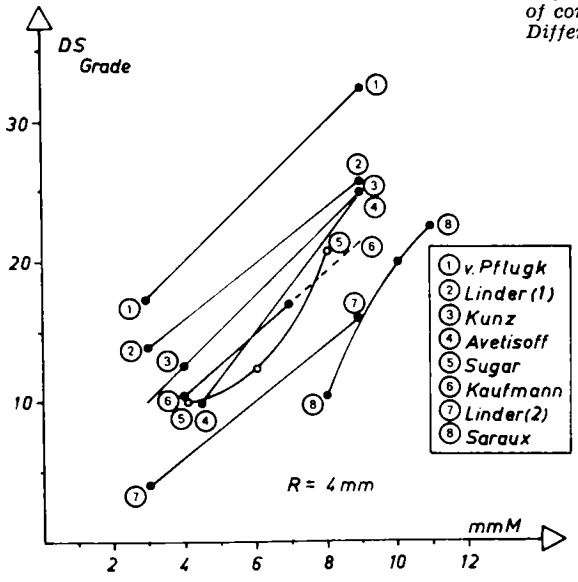
next (figure 4) shows the expected values using the geometric formula of von PFLUGK based upon a particular extent of resession of the M. rect. int., using the biometric formula of LINDER, and using the results of the empical studies of KAUFMANN. For both the latter two series, it is striking that the slopes are very similar. KAUFMANN's values lie, however, considerably lower than those calculated by LINDER. This is shown in (figures 5 and 6), in which the expected values from the formula of HACKER and of an empirical calculation formula are also indicated for a recession of 4 or 5 mm.

In spite of the fact that statistical treatment was for the most part lacking, it emerges from the above-mentioned data collections that the relationship LINDER/one, valid for 5 of the 6 participating surgeons, lies strinkingly high, where as that of LINDER/two is strinkingly low. Most of the empirically-ascertained relationships lie between these two. There are two explanations for this:

1) The relationship LINDER/one has to do with especially capable surgeons. Although actually only surgeons with great experience co-opera-

FIGURE 4

Regression lines for the effect of combined squint operations. Different degrees of recession.



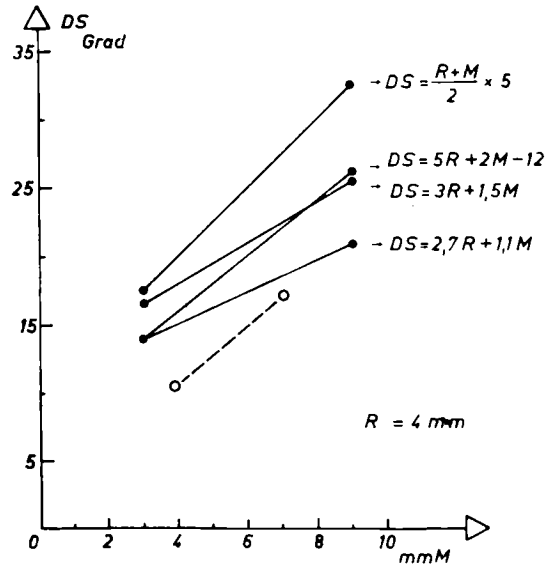


FIGURE 5

Same as Fig. 4, recession 4 mm.

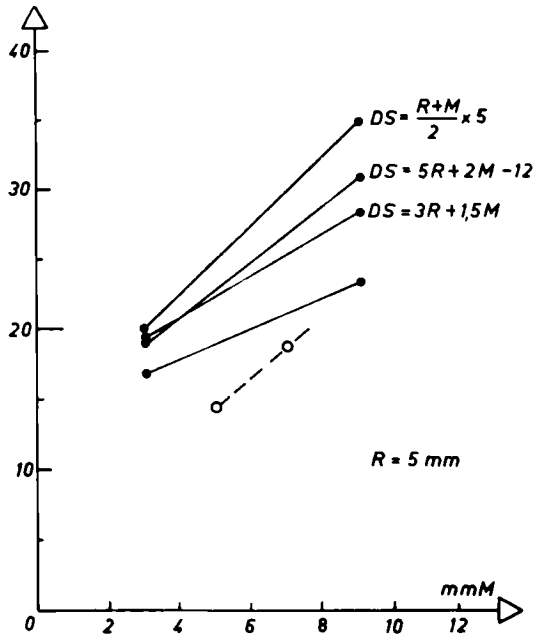


FIGURE 6

Same as Fig. 4, recession 5 mm.

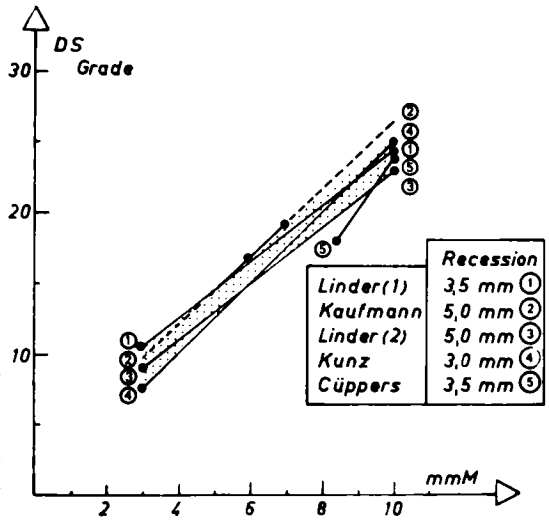


FIGURE 7

Biometrical formula LINDER (1) for recession = 3,5 mm. and LINDER (2) for recession = 5 mm., compared with the geometrical expectation values of KUNZ and the empirical data of KAUFMANN and CUPPERS.

ted in this group, the deduction is false that such surgeons achieve more with a particular extent of squint surgery than other surgeons. This is seen in that the surgeon whose results conformed to the values expected from the formula LINDER/two had performed best with respect to achieving surgically a parallel alignment of the eyes, as well as with respect to the variation of the accomplishment of squint angle correction.

2) The method of the operative procedure and specially of measuring is different for different surgeons. Pointing best to this as being the actual reason for the appearance of differences is a procedural movie of an operation which was shown by the surgeon for whom the LINDER/two formula was valid.

In the study guided by LINDER it was agreed that:

a) In recession of the M. rect. int., the distance between the old attachment and the placement of the suture for the new attachment shall be measured. According to the considerations of KUNZ, the new attachment likely lies further to the rear than would be expected from this measurement. Comparison with the results of KAUFMANN yields conformity when the recession of 5 mm. in the LINDER series is reduced to 3.5 mm. This corresponds anew to the concept and results of KUNZ (figure 7).

b) In resection of the M. rect. ext., the length of the muscle stump actually out according to the measurements is grasped, and, as the suture must be inserted a bit further peripherally, the actual shortening of the muscle is more extensive than expected from the measurements. This furthermore explains how greater changes of the squint angle can be reported with this procedure.

From (figure 7) it may be seen that, with regard to the various procedures for measuring the recession, an extensive conformity between the calculated expected values and empirical data can be achieved. Within the cross-hatched area in (figure 7), it is possible to discern with high probability a mean expected value for the given extents of resection and recession. It is however, surely expedient for each surgeon to have an operative procedure guide at hand, to which he could refer to maintain a reasonable uniformity in his operating and measuring techniques. We may not forget that there can be considerable variations above or below the relatively narrow-bordered area of average values.

We have compared 22 cases operated upon 1973 in the Institute for Experimental Ophthalmology by either METZLER or WEIGELIN with the expected values from the series of KAUFMANN. Table 2 shows that the expected value in almost half of the cases varied by degrees or less, and only in 4 cases was the variation more than 6 degrees. Unfortunately the mathematical evaluation of the results of KAUFMANN is not yet completed.

Deviation from Expectation							
Grade	> 9	> 6→ 9	> 3→ 6	3→ -3	> -3→ -6	> -6→ -9	> 9
n	2	1	1	10	7	1	0

TABLE 2

Aberrations from the empirical data for combined squint operations after KAUFMANN (see Fig. 2).

Nevertheless the results of our studies may be formulated as follows:

One can calculate the extent of the combined resection and recession operation, either when he wishes to rely upon a particular measuring technique in the operation or when he makes full use of the results of his own individual operative procedure utilizing biometrical techniques.

SUMMARY

The author begins by mention ing the great help that other sciences such as mathematics and statistics may lend to medicine, noting that they had not been used in past decades.

He also presents formulas to calculate the amount of muscle to be operated, in order to attain the desired correction.

Due to variations which occur from patient to patient and from surgeon to surgeon, as a main issue he points to a biometric study whose success depends on factors such as standarization of methods and operatory techniques, and tables containing a list of results and influential factors as well as another one of computable errors.

The author ends by analizing Linder's, Kaufmann's and his own work, and presenting tables of results as well as his conclusions.

C. J.