

## COMMUNICATIONS

### SECTORAL DISTRIBUTION OF GONIOSYNECHIAE\*

BY

CALBERT I. PHILLIPS

*From the Glaucoma Clinic, Institute of Ophthalmology, University of London  
Director of Research: Sir Stewart Duke-Elder*

It is the general opinion that, in eyes suffering from closed-angle glaucoma, goniosynechia are not uncommon, especially if such eyes have had an acute or sub-acute attack of hypertension. The present investigation has been undertaken to ascertain whether these goniosynechia are distributed at random round the angle or, as clinical impression suggests, tend to occur more in the upper than the lower half; it includes a similar survey of closed-angle glaucoma in the chronic phase and of simple glaucoma. Barkan (1938) mentioned that peripheral anterior synechia tend to occur first superiorly in the angle.

#### Material

The observations made by gonioscopy are recorded for every patient attending the Glaucoma Clinic at the Institute of Ophthalmology. These patients come mainly from Moorfields, Westminster and Central Eye Hospital, although some are sent from other sources. They are often problem cases and are referred for assessment by special investigations such as outflow tests which are difficult to arrange in a busy out-patient department. This sample is not therefore selected at random from London's glaucoma population but bias which may be present can hardly affect these gonioscopy records.

#### Method

The case-sheets of the first 1,600 patients who have attended the Glaucoma Clinic were examined. Their diagnoses include glaucomas of all kinds, some doubtful cases, and some "not glaucoma". For the present purposes, only those patients definitely in the following three diagnostic categories were selected:

- (a) acute closed-angle glaucoma; its pre-glaucomatous stage; the quiet phase following an acute "attack" if it had resolved without surgical intervention;
- (b) chronic closed-angle glaucoma;
- (c) simple glaucoma.

No eye with goniosynechia was included if there had been a history of previous operation, perforating injury, or inflammation. If any doubt existed about the presence of synechia, or if (as in a few cases) no specific note was made of their actual position, these eyes were excluded.

When records of a suitable case were found, the presence of a synechia in a given sector of the angle was indicated by a dot in the appropriate part of a concentric histogram

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(Fig. 1). For example, if, on the gonioscopy case-sheet, was recorded "synechia between ten and two o'clock", then a dot was placed in the sector corresponding to each of the 10, 11, 12, 1, and 2 o'clock positions; the radial lines from the centre of the clock face cut the circumference at each half-hour. The next suitable eye in the same diagnostic category was treated in the same way and credits were made in the same diagram, the composite histograms for right and left eyes being kept separate. For the purposes of this survey it was unnecessary to differentiate between a small synechia and extensive synechia within a given sector, a single credit being placed on the diagram in each case.

Since none of these eyes was examined by the writer, observational bias cannot render the results nugatory.

#### Diagnostic Criteria and Terminology

The usual methods of investigation (excluding tests used for research purposes) are as follows: history, both general medical and ophthalmological; clinical examination (including refraction and bio-microscopy); scotometry, campimetry, gonioscopy, and tonometry; provocative tests (dark-adaptation and water-drinking); outflow tests (tonography or bulbar pressure).

Very few eyes with closed-angle glaucoma were examined in the acute hypertensive state. Accordingly, most of the cases included in Group *a* had previously suffered an episode of hypertension which had resolved without operation, or had experienced the recurrent premonitory symptoms of a rise of tension, and/or had shown positive results with provocative tests.

"Chronic closed-angle glaucoma" (Group *b*) includes eyes which have usually narrow, almost completely occluded angles, and a tension which is constantly raised or seldom normal. The end-stages often resemble those of simple glaucoma clinically, but the history and gonioscopy findings are usually enough to differentiate the two. It cannot be denied, however, that some of these cases must have true chronic simple glaucoma combined with an inherited narrow angle (Törnquist, 1953), or must suffer from both diseases.

The term "simple glaucoma" (Group *c*) needs no further definition.

All doubtful cases have been excluded, so that the total number in the survey does not indicate the true proportion of closed-angle glaucoma in the 1,600 case histories examined.

#### Results

(*a*) *Closed-angle glaucoma in its acute, pre-glaucomatous, or quiet phases.*—The composite histograms for these cases are presented in Fig. 1 (opposite).

The mean incidence of goniosynechia per sector in the right eye is 11 and in the left 15.3. If the risk of each sector's developing a synechia were equal, then the sectoral incidence should not vary significantly from that mean. If this null hypothesis be applied to the data in Fig. 1 in the form of the  $\chi^2$  test ( $\chi^2 = \sum \frac{(O - E)^2}{E}$ ; Brownlee, 1949), it is clear that the variation in frequency per sector is extremely unlikely to be found by chance\*.

(*b*) *Chronic closed-angle glaucoma.*—The composite histograms for these cases are presented in Fig. 2 (opposite).

In both right and left eyes the distribution of goniosynechia is probably random†.

\* For the right eyes,  $\chi^2 = 42$ ;  $n = 11$ ;  $P$  much  $< 0.01$ ;  
for the left eyes,  $\chi^2 = 23.9$ ;  $n = 11$ ;  $P < 0.02$ .

† For the right eyes,  $\chi^2 = 1.86$ ;  $n = 11$ ;  $P > 0.99$ ;  
for the left eyes,  $\chi^2 = 4.41$ ;  $n = 11$ ;  $P > 0.95$ .

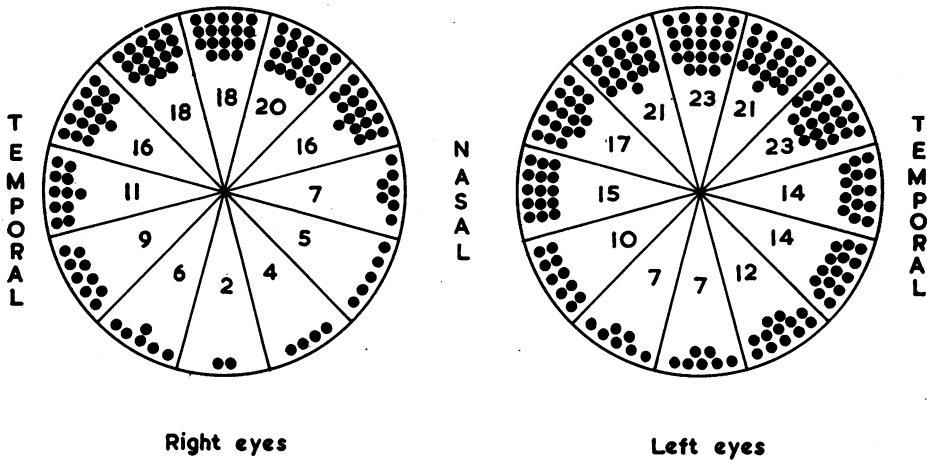


FIG. 1.—Sectoral distribution of goniosynechiae in closed-angle glaucoma in acute, pre-glaucomatous, or quiet phases. Composite histograms for 20 right and 27 left eyes. Figures in each sector of the clock face indicate total synechiae found therein.

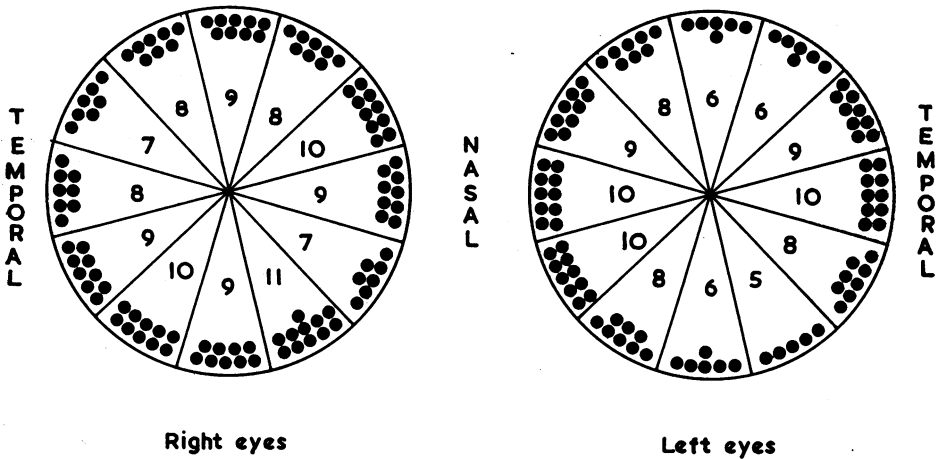


FIG. 2.—Sectoral distribution of goniosynechiae in chronic closed-angle glaucoma. Composite histograms for 11 right and 10 left eyes. Figures in each sector indicate total synechiae found therein.

At first sight it is surprising that the tendency for goniosynechiae to occur superiorly is not evident in this type of case; wide areas of synechiae above and none at all over a small area below might be expected. The temptation to conclude that these eyes, although having narrow angles, had no sectoral variation in the depth of the angle should be resisted. This fallacious conclusion is due to the method of recording, which allots a credit to a sector whether a synechia is narrow or broad. Re-examination of the gonioscopy records from the standpoint of the distribution of open areas of the angles reveals that gaps tend to occur more often and over larger areas inferiorly.

(c) *Simple glaucoma*.—The meaning of the term “goniosynechia” applied in cases of simple glaucoma in the absence of previous injury, operation, or inflammation, will not be defined. For the purposes of this investigation, eyes in which observers have recorded “synechia” have been included (Fig. 3).

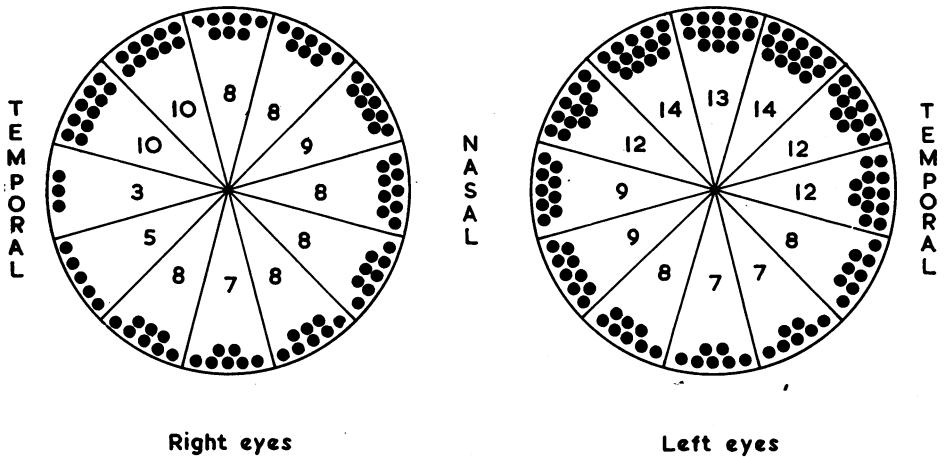


FIG. 3.—Sectoral distribution of goniosynechia in simple glaucoma. Composite histograms for 25 right and 24 left eyes. Figures in each sector indicate total synechia found therein.

The “goniosynechia” in the right eyes are probably distributed at random, as also may be those in the left, but in the latter there is a definite tendency to favour the upper segments, although it is far from the usually required 95 per cent. level of statistical significance\*. Perhaps the study of more cases would decide the issue.

### Discussion

The tendency for goniosynechia in closed-angle glaucoma to occur in the upper parts of the angle is doubtless associated with the increased shallowness of the narrow angle in that region. The possible causes of this anatomical peculiarity and its significance are discussed in the following article (Phillips, 1956).

Fig. 1 shows that there is a tendency for the temporal side to show a slight excess of synechia over the nasal. In other words, if the totals in each nasal sector are subtracted from those in each opposite temporal sector, and the differences are summed, a positive quantity remains. In order that maximum possible numbers might be obtained, a combination of right and left eyes was made. The simplest method would have been to add the totals in the corresponding sectors of the two parts of Fig. 1 (no proof is offered for the assumption that the two eyes are mirror-images in respect of variations in numbers of synechia, etc.). However, the objection might be raised that

\* For the right eyes,  $\chi^2 = 5.57$ ;  $n = 11$ ;  $P > 0.90$ ;  
for the left eyes,  $\chi^2 = 7.58$ ;  $n = 11$ ;  $P > 0.70$ .

each eye included in the analysis would not then be as independent as possible of all others, since two eyes in one patient are more likely to be similar than two eyes belonging to two different patients. Accordingly, in bilateral cases, one eye was excluded; the left eye in the odd numbers on the list, and the right eye in the even numbers. Although there are objections to this method of random sampling, they seem to be fewer than those which could be made to other methods.

The data thus obtained are presented in Fig. 4, which again shows a tendency for synechiae to favour the temporal side. The right and left data have been combined to correspond with a single right-sided eye.

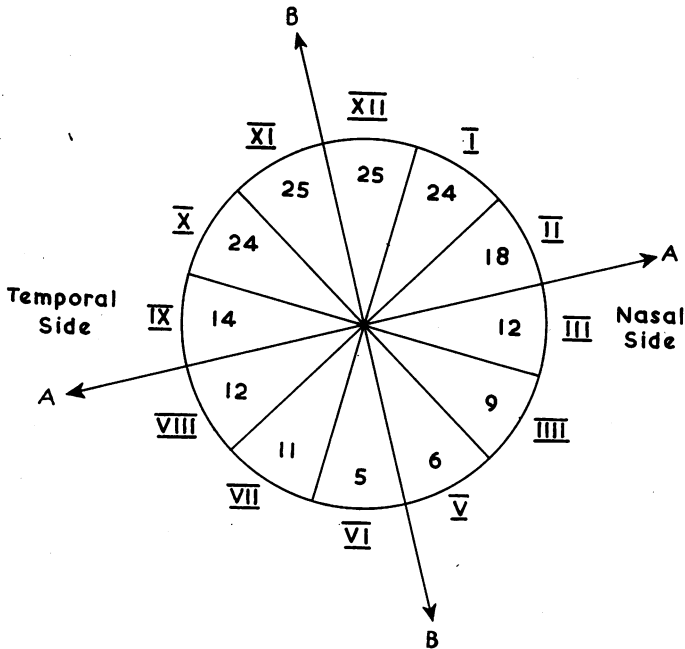


FIG. 4.—Closed-angle glaucoma in acute, pre-glaucomatous, or quiet phases. Total synechiae in each sector for right and left eyes combined (Arabic numerals), the sectors corresponding to those of a clock face being indicated by Roman numerals. The combination has been made to correspond with a single "right-sided" eye.

Inspection of Fig. 4 suggests that there is one axis round which asymmetry will be maximum, and another, at right-angles, round which symmetry may be reasonably expected. It may be noted here that this does not necessarily mean that the orientation of the lens is the cause, although that is a tempting assumption.

By trial and error, it is found that the axis on the two sides of which there is the greatest difference in the numbers of synechiae runs from 8.30 to 2.30 o'clock (AA in Fig. 4). This axis is not quite horizontal, the nasal end being higher than the temporal end. The mean of the differences between

paired sectors on each side of that axis is "significant" at the  $P < 0.01$  level ( $t=4.268$ ; see Table for principle of analysis).

The inaccuracies of the method of observing and recording the synechia render this axis-finding very approximate; thus, although one synechia may have occurred at, say, 8.45, and one at 9.15 o'clock, each is allotted to the 9 o'clock sector.

An axis of maximum symmetry may be found similarly. This line on the two sides of which paired sectors show least inequality in numbers of synechia, runs from 11.30 to 5.30 o'clock (BB in Fig. 4); this axis is not quite vertical, its upper end being slightly to the temporal side of 12 o'clock on the limbus. The statistical treatment of this axis of symmetry is much easier than that of the axis of asymmetry. The Table shows the sector totals taken from above downwards on each side of the 11.30 to 5.30 o'clock axis.

TABLE

*The totals of goniosynechia from the sectors in Fig. 4. The Roman numerals indicate the sectors on the clock face from which come the totals of the goniosynechia represented by the immediately preceding Arabic numerals. The test for symmetry is being applied to the axis 11.30 to 5.30 o'clock, to which "Temporal" and "Nasal" refer.*

Temporal		Nasal		Differences (Temporal—Nasal)
No. of Synechia	Sector	No. of Synechia	Sector	
25	XI	25	XII	0
24	X	24	I	0
14	IX	18	II	-4
12	VIII	12	III	0
11	VII	9	III	+2
5	VI	6	V	-1
Total Differences ... ..				-3

This axis just fails by three synechia to be exactly symmetrical, the slight excess belonging to the nasal side. Comparison of the nasal and temporal sides of the line joining 12 and 6 o'clock (assuming that the totals 25 and 5 respectively are bisected) shows a discrepancy of seventeen synechia favouring the temporal side. The conclusion seems reasonable that the upper end of the true axis of symmetry lies somewhere between 11.30 and 12 o'clock, slightly nearer the former than the latter.

The difference  $-3$  (see Table) is not statistically significant, as would be expected, even at the 90 per cent. level. Applying the  $t$  test to the mean of the differences (cf. difference of the means) shown in the Table, we have  $t=0.637$  and  $P$  much  $> 0.10$ . If the  $t$  test be applied to the 12.30 to 6.30 axis,  $P < 0.01$ , whereas  $P < 0.02$  in the case of the 10.30 to 4.30 axis; these results tend to confirm the impression that the upper end of the axis of symmetry lies to the temporal side of 12 o'clock.

On the basis of the  $t$  test, which is the simplest analytic method to apply to these data, all we are justified in saying is that the axis of symmetry, if the

possibility of its existence be admitted, runs from a point somewhere between 10.30 and 12.30 o'clock to a diametrically opposite point on the limbus.

A discussion of the significance of these findings for closed-angle glaucoma is reserved for the subsequent article (Phillips, 1956), wherein are described the gonioscopic appearances of actual cases.

### Summary

It has been shown that goniosynechia are not distributed at random round the angle in cases of acute and "sub-acute" closed-angle glaucoma, but tend to occur mainly above, the highest incidence being probably a little to the temporal side. This peculiarity has not been statistically "proved" to occur in cases of chronic closed-angle glaucoma or of simple glaucoma, but the same tendency probably exists in these eyes.

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