DISTRIBUTION OF BREAKS IN APHAKIC AND "SENILE" EYES WITH RETINAL DETACHMENTS*

BY

CALBERT I. PHILLIPS†

Bristol Eye Hospital and Department of Ophthalmology, University of Bristol

THE chief aim of this work is to compare the incidence and distribution of retinal breaks in aphakic eyes affected by retinal detachments with those in a control sample of phakic eyes with retinal detachments. The aphakic eyes were carefully selected to be as free as possible from factors other than aphakia, such as pre-operative myopia and vitreous loss, which might predispose to retinal detachment.

Shapland (1934) reviewed thirty cases of aphakic detachment, in 40 per cent. of which retinal breaks were found; these breaks were almost always confined to the temporal halves of the globes and were equally distributed between the superior and inferior quadrants. Bagley (1948) found breaks in 38.4 per cent. of cases. Schepens (1951) reported that the use of binocular indirect ophthalmoscopy and the increasing popularity of the intracapsular technique of operation had raised the proportion of aphakic detachments in which breaks were detected to 97.5 per cent. Schepens and Bahn (1950) and Schepens (1951) stated that in 66 per cent. of aphakic detachments these breaks tended to be peripheral, multiple, and minute; small dialyses, and breaks closely related to meridional folds, were common. Welch (see Maumenee, 1957), however, in a review of cases seen between 1953 and 1956 at the Wilmer Ophthalmological Institute, Johns Hopkins Hospital, noted that 75 per cent. of breaks occurred at the equator. Toselli and Venturi (1959) reported ten cases after intracapsular cataract extraction in which, by a small majority, breaks tended to be on the temporal rather than the nasal side and near the ora rather than the equator; seven of the eyes had "horseshoe" tears.

Materials and Methods

Case records obtained from the Retina Service of the Massachusetts Eye and Ear Infirmary and from the private offices of the Retina Associates, Boston, Massachusetts, included private and hospital patients attending between February, 1958, and June, 1960, who came from a wide geographical area, mainly in the U.S.A. No selection of case records was made on grounds of nationality or race.

Cases of aphakic detachment with the following characteristics were selected:

(a) No previous operation except for cataract extraction.

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- (b) Absence of significant history of injury or inflammation pre- or post-operatively.
- (c) Intracapsular type of operation performed after the age of 50 years.
- (d) Extraction uncomplicated by vitreous loss, hyphaema, etc.
- (e) Refraction before operation emmetropic or hypermetropic.
- (f) No ocular disease other than the cataract, *e.g.* glaucoma or iridocyclitis.
- (g) No general disease, *e.g.* diabetes mellitus or hypertension with retinopathy, which might have contributed to the cause of the detachment.
- (h) No suspicion that the detachment preceded the cataract.

In order that each observation should be as "independent" as possible of all others, one eye only of bilateral cases was included, alternate right and left eyes being selected. Long-standing detachments (*i.e.* over 6 months' duration) were usually excluded, especially where degenerative changes and "massive vitreous retraction" and fixed folds might obscure breaks.

Complete certainty on all of these criteria cannot be claimed. "Significant" history of injury was equated with direct trauma to the eye itself. As regards shortcomings of the analysis, the patient might have forgotten such a possibly relevant episode. Also, the history supplied by the referring surgeon might well have been reticent about vitreous loss which could not always be detected by examination at the time of the retinal detachment; this probably constitutes the most serious defect in the analysis. Pre- and post-operative prescriptions for glasses were sometimes missing, so that the history had sometimes to be accepted on the pre-operative refractive state; when serious doubt existed, the case was excluded from the series. It is quite possible that some of the cases included had in fact had unsuspected retinal detachment before the cataract operation.

In an extremely small proportion of cases (2.5 per cent. or less as previously recorded by Schepens, 1951) no break was found; these tended to be cases of long-standing detachment. They were excluded. The existence of "doubtful" breaks was usually confirmed or refuted by diathermy at operation; if not, "probable" breaks were accepted and "possible" breaks rejected.

Unfortunately, there was usually no information about the technique of cataract extraction (tumbling or sliding, erisophake or forceps, with or without chymotrypsin). Of great interest would be the relationship of aphakic detachment to the use of chymotrypsin.

Where appropriate, the same limitations were imposed on the control sample which was selected from patients attending between October, 1958, and June, 1960. Controls were relatively more numerous so that it was possible to match each aphakic patient with a control:

- (i) Of the same sex.
- (ii) With the same eye affected.
- (iii) Of the same refraction within the range ± 0.50 of the aphakic's estimated pre-operative state (+10 D sph. was taken as the expected refractive error of a pre-operative emmetrope—although Boeder (1962) suggests +11 D); a spherical equivalent of half the astigmatic error was used in the calculation, but all patients suspected of even the smallest degree of pre-operative myopia were excluded.

(iv) Of the same age—identical in most cases but within the range ± 2 years in the small proportion where complete identity was impossible; when a control of the aphakic's age $+1$ or $+2$ years was accepted, in the next case where an exact match for age could not be found, a control of the aphakic's age -1 or -2 years respectively was chosen. That some of the controls had lens opacification does not detract from the validity of the differences found between the two groups; indeed, the controls should, ideally, have had lenses opaque enough to warrant operation! Where satisfactory ophthalmoscopy was prevented by cataract, that control case had to be rejected.

Controls and aphakics alike were all examined by the same four ophthalmologists, none of whom tended to see any specialized type of case; all had extensive experience in binocular ophthalmoscopy and in making drawings on the standard fundus charts.

When a retinal detachment increases in elevation, a break moves towards the centre of the globe although it does not alter its distance from the ora serrata to any important extent; the exact appearances as seen are recorded on fundus charts without any allowance for alteration in the position of the break due to elevation of the detachment. Since the statistics to be discussed have been obtained directly from the fundus charts, the distribution of retinal breaks is apparent rather than actual. The problem of correcting the sites of breaks is a difficult one because of the many more or less immeasurable variables related to the detachment itself:

- (a) The height of the detachment which is difficult to estimate,
- (b) The tautness or folding of the retina between the break and the ora or other fixed landmark,
- (c) The dimensions of the eyeball,
- (d) Distortion due to peripheral optical aberrations,
- (e) Distortion produced by scleral depression which was often the only means by which breaks could be seen.

Accordingly, it was decided to accept the inherent defects in the fundus drawings, especially as the control sample could be expected to suffer the same order of variations of sites of breaks as the aphakic sample. Stine (1952) reviewed the literature and reported his original work on correcting the observed sites of breaks; he also pointed out that, when a retina flattens, a break not only shifts in an antero-posterior direction but also in a direction parallel to the equator.

Other Possible Sources of Error

The depth of the anterior chamber and the presence of the lens are the main factors which could produce a consistent discrepancy between the two groups in the plotting of breaks. Schepens and Bahn (1950), found that the sclera of an aphakic eye could be illuminated through the pupil further anteriorly than that of a phakic eye, because peripheral rays are eliminated by total internal reflexion in

the crystalline lens and because the lens (by its plate-glass-with-prismatic effect) directs rays with an oblique incidence more posteriorly than in the aphakic state. Both these factors overcome the slighter effect of increased depth of anterior chamber in the aphakic eye which reduces the ability of entering light rays to reach the peripheral fundus. Accordingly, if the observer uses the angle between his line of vision and the patient's optic axis as a means of plotting a peripheral break (as happens to some extent when landmarks such as the ora serrata, vortex veins, and disc are not visible within the same field as the break), then he will tend to plot it in a phakic detachment more anteriorly than if the same eye were aphakic. This would produce a bias against the results to be reported (a negative, or in this case "inhibiting", contaminant—Atkins, 1958), so that its effect can safely be ignored. On the other hand, the smaller magnification of an aphakic than a phakic fundus would tend to make an observer plot a break at a smaller distance from a landmark in the former than in the latter; however, since aphakic breaks tend to be situated at or very near the ora, this effect must be small and is probably "neutralized" to some extent by the reduced amount of optical distortion of the peripheral fundus in an aphakic eye.

It might be expected that aphakic eyes more often had total detachments than phakic eyes, a difference which would be reflected in the distribution of breaks if it be admitted that breaks may follow detachments. However, the slightly greater tendency for total detachments to occur in the aphakic group (30 out of 105* compared with 24 out of 106* in the controls) was not significant (probability > 50 per cent. but < 90 per cent.). Also, the mean area of the diagrams which the detachments covered—estimated from the number of squares of a grid involved by the detachment—was slightly less in the control phakic sample (62.9) than in the aphakic (70.4), but not significantly so (probability < 90 per cent. by the *t* test).

Since a small peripheral detachment in an aphakic eye may remain sub-clinical longer than in a phakic eye, either because of poor vision if no glasses are worn or because of the restricted peripheral field if an aphakic correction is worn, it might be expected that retinal detachments in aphakic eyes were of longer duration than those in phakic eyes; therefore, they might tend to have more breaks. However, the histories were usually surprisingly specific about the suddenness of onset of symptoms ("floaters" or field defects) so that a comparison of durations, or apparent durations, was possible in the vast majority of cases. The mean duration of aphakic detachments was 40.1 days compared with 61.3 days in the controls—not a significant difference (probability much < 90 per cent; *t* test) because of the wide variance between cases.

Results

The mean age of the 112 patients with aphakic detachments was 64.29 years (SD=6.9). The detachment had appeared within 3 months of operation in 12.5 per cent. cases, between 3 and 12 months after operation in 25.9 per cent., between 1 and 5 years after operation in 41.1 per cent., and more than 5 years after operation in 20.53 per cent.

* Each of the original groups contained 112 cases, however. Not quite all of these cases could be traced when a subsequent re-check of area of detachments was made; however, there is no reason to suspect an association between area of detachment and difficulty in tracing the "missing" records.

Fig. 1 shows the distribution of retinal breaks in aphakic eyes; the control sample is shown in Fig. 2.

Breaks have been classified into:

- (i) "Arrow-head" or "horse-shoe" tears
- (ii) Round or oval holes.

There were 112 aphakic eyes with a mean of 2.098 breaks per eye (SD 1.85) (*cf.* Schepens, 1951, who found 4.45 breaks per eye, but his cases were more heterogeneous than the present series). In the control group, with the same total number (112), the mean number of breaks per eye was 2.143 (SD 1.78).

FIG. 1.—Distribution of breaks in detached retinæ of aphakic eyes which were emmetropic pre-operatively and in which operation was performed after the age of 50 years. The outermost ring indicates the junction of the pars plana and ciliary body and the next the ora serrata; the next but one indicates the equator and the intermediate ring is midway between and bisects that distance. The rings within the equator are drawn at the same, or double, the intervals as measured on the diagram.

Neither the two means (by the *t* test) nor the two variances (by the *F* test) differed significantly.

Figs 1 and 2 show that the upper half of the retina is the more frequent site of breaks, but this tendency is more marked in the phakic than the aphakic group. In the phakic group the superior breaks are more often in the temporal quadrant whereas in aphakic eyes they are more often in the nasal quadrant. Breaks in aphakic eyes tend to occur more peripherally than those in phakic eyes. The holes are more often round or oval in aphakic than in phakic eyes.

Within the aphakic group, the eyes suffering detachment within one year of operation were compared with others. Breaks located anterior to the equator tended to occur nearer the ora than the equator within one year of operation. A higher proportion of superior breaks occurred more than one year after operation.

FIG. 2.—Distribution of breaks in detached retinæ of phakic emmetropic eyes, each one paired with one in Fig. 1 in respect of age. The outermost ring indicates the junction of pars plana and ciliary body, the next the ora serrata. The next but one indicates the equator while the intermediate one bisects that distance. The rings within the equator are drawn at the same, or double, the intervals as measured on the diagram.

Statistical Analysis

When the χ^2 test was applied to the aphakic eyes and the control phakic eyes to evaluate the proportions of eyes in which breaks were situated (*i*) superiorly, (*ii*) inferiorly, and (*iii*) both superiorly and inferiorly, the differences did not reach a satisfactory level of significance. The other tendencies mentioned under "Results" were also "not significant". Nevertheless the results (Figs 1 and 2) seem to be of enough clinical importance to be worth recording.

Discussion and Conclusions

That the incidence of retinal detachment is greater in aphakic than phakic eyes would be generally agreed without statistical proof. Aetiological considerations can be divided into four groups:

(1) No new factors need be invoked to explain some detachments in aphakic eyes because these would have occurred in the phakic state. Also, in some cases, a coincidental detachment may exist undetected before the operation (Schepens, 1951), and may not become clinically manifest until years later.

(2) A cataract and retinal detachment may both be due to a common cause, *i.e.* the retina of an eye which develops a cataract may also contain abnormalities which lead to an "aphakic" type of detachment. One known example is that of peripheral uveitis with exudate in the region of the ora serrata (Schepens, 1950a, 1951).

(3) Factors which are believed to produce retinal detachment in phakic eyes—degeneration and detachment of the vitreous (Alajmo, 1952; Teng and Chi, 1957; Lorente Buesa, 1958 and Schiff-Wertheimer, 1958), increased mobility (Hilding, 1954) of the vitreous, vitreo-retinal adhesions to areas of retinal abnormality, and ability of the potential intra-retinal space to become actual—are merely precipitated or aggravated by the cataract extraction or the aphakic state. A chronic post-operative iridocyclitis would probably produce or aggravate vitreous retraction (Mauernee, 1957). "Massive vitreous retraction" (Schepens, 1951) tends to affect aphakic eyes more than others; it is recognized by the height and immobility of retinal folds clustered round the disc which is just visible deeply among them; these folds radiate outwards to the equator where a high meridional fixed fold tends to limit them anteriorly. The fact that the breaks in aphakic detachments are more often peripheral may be due to lack of support by the lens which permits a more extensive detachment of vitreous anteriorly. (Peripheral adhesion between vitreous and retina is increasingly extensive with increasing age, however: Teng and Chi, 1955.)

(4) Although these three considerations must apply in some cases, the differences in distribution of the breaks in the aphakic and control groups analysed above suggest that other factors exist. The most important may be traction on the suspensory ligament of the lens at the time of operation; this would be transmitted to the ora serrata, especially to its teeth, from which fibres sometimes originate (Vail, 1957) and where breaks tend to occur in

aphakic eyes (Schepens, 1951). Vail (1957) suggests this as the mechanism of retinal detachments occurring soon after operation; however, it seems possible that a break situated anterior to the zone of posterior vitreous detachment (see also Wolter and Wilson, 1950) may not immediately produce a retinal detachment, although a small overlying zone of liquefied vitreous, with traction on edges of the break, may exist. The tendency of superior breaks in aphakic eyes to be situated medially may be related to the prominence of individual folds on the teeth of the ora serrata on the nasal side, or even conceivably to the greater and firmer insertion of the fibres of the suspensory ligament on the nasal side where the distance between the ora serrata and the equator of the lens is shorter. The tendency for breaks in aphakic eyes to occur inferiorly may be explained by the greater traction on the inferior fibres of the suspensory ligament when a lens is tumbled. Furthermore, almost all methods of cataract extraction involve indentation of the globe inferiorly and this may stretch the retina to break in abnormal or thin areas, especially the walls of cysts or areas of retinoschisis. Operative or post-operative hypotony may cause folding and oedema of the retina, if not transient accumulation of fluid in the intra-retinal space, so that breaks may appear at the edge of awkwardly-placed spots of ankylosis retinae (*i.e.* areas where the two layers of the retina are bound together from whatever cause).

Summary

The distributions of retinal breaks have been compared in two groups of patients:

(a) Those with eyes aphakic because of uncomplicated intracapsular operations performed after the age of 50 years in pre-operative emmetropes or hypermetropes who had no other eye disease (*e.g.* previous significant injury, iridocyclitis) or general diseases (*e.g.* diabetes mellitus) which could conceivably contribute to retinal detachment. Unfortunately, all cases of vitreous loss during cataract extraction may not have been excluded owing to under-reporting.

(b) A control sample matched for age, sex, side affected, absence of myopia, absence of history of injury, etc.

Compared with the controls, the aphakic eyes tended to show breaks which were more often peripheral, more often inferior, and more often superonasal. Breaks in aphakic detachments appearing less than one year after operation tended to be more often peripheral than those which appeared more than one year after operation. The aphakic and control groups did not differ significantly in the incidence of total detachment or in the mean area of fundus affected by detachment; accordingly, the position of retinal breaks in the two groups would probably appear to be shifted by detachment to a similar extent. The sites of holes were plotted directly from the fundus charts which record exactly what is seen with the ophthalmoscope.

Factors biasing an observer towards plotting breaks more posteriorly in aphakic eyes are probably cancelled out by factors which tend in the opposite direction. However, breaks are usually plotted in relation to landmarks, especially the ora serrata in pre-equatorial breaks, so that differing magnification is probably the most important factor; since the distance between breaks and landmarks, especially in the pre-equatorial region, is small, the effect is probably negligible.

Although it is admitted that the "aphakic" group must include eyes which would have suffered a retinal detachment even if they had remained "phakic", and must also include eyes which developed a retinal detachment merely because of the precipitation and aggravation of such pre-disposing factors as detachment and increased mobility of the vitreous, it is considered that in a significant proportion of aphakic eyes the breaks are produced at the time of the operation by traction on the fibres of the suspensory ligament of the lens which are inserted into the teeth of the ora serrata: since these breaks are situated in front of the usual anterior limit of vitreous detachment, there may be a long period before the detachment occurs.

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