COMMUNICATIONS

VISUAL FIELD CHANGES PRODUCED BY X-RAY TREATMENT OF PITUITARY TUMOURS*

BY

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DURING the past 10 years I have had the opportunity to examine ophthalmologically at least 180 patients with pituitary tumour treated with x rays. Approximately 150 of these had chromophobe adenomata and thirty had eosinophilic adenomata. It is certainly not my intention to discourse on the type of therapy, mode of application, or dosage. Suffice it to say that most of our cases were treated with an average total tumour dosage of 3,000r. This was usually divided into three courses of approximately 1,000r, each course lasting from 4 to 6 weeks, with an interval of 3 to 4 weeks between courses. In a few cases the treatment was given as a single course and completed in 6 to 8 weeks, and in a few others it was extended over a period as long as 6 to 8 months.

Radiotherapists and neuro-surgeons have written a good deal about this subject in recent years, but the ophthalmologists have said relatively little, and it is the purpose of this paper to present the subject from the ophthalmologist's point of view.

Selection of Cases

In order to evaluate the effect of x-ray therapy the following cases were omitted from this study:

- (1) Those treated primarily by surgery but in which x ray was given immediately post-operatively.
- (2) Those in which adequate follow-up visual field studies could not be obtained.
- (3) Those seen in consultation on only one or two occasions, either for diagnostic purposes or as a guide to therapy.
- (4) Those with clinical evidence of pituitary tumour but without involvement of the visual fields.

In other words, this study included particularly those cases in which the patient was observed during treatment and for a reasonable number of months or years afterwards. Only in four cases was treatment completed before the patient was first seen by me, but was followed thereafter. In three cases, surgery had been performed several years before but, with

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recurrence of symptoms including visual loss, radiotherapy was started again and the results of treatment are recorded here.

Because of selectivity, therefore, of over 180 such cases observed in the past few years, only forty were found suitable for inclusion in this study.

Method of Following Cases Ophthalmologically

The treatment of these patients, like the diagnosis in their cases, is best carried out by the concerted efforts of a team consisting of neuro-surgeon, roentgenologist, and ophthalmologist. In diagnosis, the role of each is quite elementary and needs no further explanation here. As to treatment, after making a definite diagnosis, the neuro-surgeon is the person to decide that radiotherapy rather than surgery is the treatment of choice. Generally speaking, radiotherapy is administered in cases of chromophobe or eosinophilic adenoma in which severe loss of central vision is not immediately threatened and in which there is no clear evidence of cyst formation. Complete ophthalmological examination is carried out before starting treatment. Other ophthalmological changes, such as optic atrophy, muscle palsy, etc., may be produced by pituitary tumours (Chamlin, Davidoff, and Feiring, 1955), but our particular concern is the central visual acuity as measured on the Snellen chart (hereafter referred to as central visual acuity) and the field of vision. Central visual acuity is noted after the best possible refraction has been done. Thereafter, the patient must be allowed plenty of time in which to read as far down on the chart as he possibly can, even if he reads only the figures on the nasal side of the chart. In such cases one may assume that with proper fixation of gaze he could read the rest of the line. If a patient has involvement of the visual field close to fixation, the ability to read the Snellen chart may depend on the fortuitous fixation of the eye, which may or may not bring the characters into the best portion of the retina close to the fovea. Therefore it is only by encouraging the patient to take enough time and thereby to force his perception as far down the chart as possible that central visual acuity may be evaluated and considered accurate enough to use for comparison with future readings as an indication of improvement or otherwise. Without such careful examination the examiner may be trapped into a false sense of security when a patient happens to read better on a subsequent visit because he takes more time to find the characters. On follow-up examinations, a small amount of extra concave lens is occasionally necessary to bring out the patient's best central visual acuity. That this is sometimes necessary may possibly be due to some accommodative spasm occasionally seen in these anxious patients.

The peripheral visual fields are examined with 2/330 white, and the central fields with 1/2000 white. If, with these tests, the fields are found to be full, "minimal" techniques (Chamlin, 1949) are employed to bring out early defects (Fig. 1, opposite). For detecting early and minimal defects due to chiasmal interference, the study of the 1/2000 field seemed to be extremely

FIG. 1.—Case 34 in Table II, 52-year old male. Eosinophilic adenoma, showing minimal involvement of 1/2000 field only, brought out by “level differences” (Chamlin, 1949).

A. Jan., 1956, before treatment. Slight encroachment of left temporal paracentral field.

Treatment Jan.–Feb., 1956.

B. Apr., 1956, 2 months after treatment. Nasal field goes out to 15°, showing bitemporal defect.

C. Oct., 1956, 8 months after treatment. Almost complete filling out to the 15° arc and a little beyond in the temporal field horizontally.

useful. It is well known that the peripheral field for 2/330 white may be completely normal while that for 1/2000 white may show definite bitemporal hemianopia (Figs 4 and 8). The 2/330 white and 1/2000 white fields were found to be most useful. The 1/330 white, while occasionally showing slightly more involvement than the 2/330, was not found to give enough extra information to make it worthwhile using routinely. On the other hand, the 1/2000 field has been found to show chiasmal interference earlier and more extensively than the peripheral field examination (Chamlin and Davidoff, 1950).

As for the use of the 2/2000 field, I have not yet fully explored this isopter. One of the reasons is that the field for this visual angle is often found to extend beyond the usual useful arcs on the 2-metre screen, thus introducing an element of inadequacy of the surface area, as well as the additional error

FIG. 2.—Case 1 in Table II, 50-year-old male. Chromophobe adenoma, showing maintenance of visual status.

A. Jan., 1951, before treatment.

Treatment 1951–53. Visual acuity 20/30 in each eye.

B. May, 1951, some dubious improvement in quality of temporal paracentral field in each eye.

C. Jan. 1957, maintenance of visual status after 6 years. Visual acuity 20/30 in each eye.

introduced by the greater tangential difference in visual angle size encountered beyond the 20 or 25° arc. However, judging by some of the cases, it may well be that an isopter immediately peripheral to the 1/2000 field, which I prefer to call the “intermediate field”, may show more evidence of early chiasmal interference than does the 1/2000 isopter, and we are currently engaged in studying and designing equipment for investigation of such an isopter. Thus far, however, we have found 2/330 and the 1/2000 fields most useful for following cases of chiasmal interference. The 1/2000 field is particularly useful, since it offers a wider range of evaluation of quality as a gauge of improvement than does the peripheral field. When examinations are performed frequently enough, examination of the 1/2000 field alone is often quite satisfactory.

In cases which show loss of field for these visual angles, the defective areas should be “qualified” (Chamlin and Davidoff, 1952). This is an expedient method of judging progress without doing complete field studies with numerous test objects. Briefly, this consists of exposing larger and larger test objects in the defective area until one of them is recognized by the patient.

FIG. 3.—Case 8 in Table II, 47-year-old male. Chromophobe adenoma, showing poor response. This patient had had treatment before coming under observation.

A. Dec., 1952, visual acuity 1/400 in the left eye and 20/200 in the right.

B. Apr., 1953, slight improvement in left eye; worse in right eye.

More treatment Apr.–May, 1953.

C. Sept., 1953, visual acuity 20/200 + 1 in the left eye and 20/50–1 in the right. Slight improvement in some areas.

D. Dec., 1954, visual acuity 12/200 in the left eye and 20/100 in the right. Loss in both eyes.

E. Mar., 1955, further loss. Visual acuity in the left eye counting fingers, and 20/100 in the right.

F. June, 1955, further loss. Visual acuity in the left eye no hand movements, and 20/100 in the right.

The patient was operated on and the removal of a large cystic chromophobe adenoma was followed by considerable improvement.

FIG. 4.—Case 36 in Table II, Case 9 in Fig. 9, 25-year-old male. Chromophobe adenoma.

A. Sept., 1952, before treatment. Visual acuity 20/30 each eye.

Treatment Sept., 1952–July, 1953.

B. July, 1953. Visual acuity in the left eye 20/20 and 20/20–2 in the right. Note marked improvement in quality of the temporal fields paracentrally in each eye.

C. July, 1954, definite improvement 1 year after completion of treatment. Visual acuity 20/20 each eye.

D. Feb., 1955, further improvement 1½ years after completion of treatment.

Thus, the number “5” indicates that this is the smallest test object visible to the patient at that point in the field.

Following one or more preliminary field and visual acuity studies, the patient is given his first treatment and then re-examined, if possible, within 24 hours. If no further encroachment takes place (if encroachment does occur it is believed to do so because of reactive oedema due to treatment), the patient receives two more treatments on alternate days and is then examined again. If there is still no further encroachment on the visual field, re-examination may then be made at 3- or 4-day intervals while treatment is carried out three times a week. These examinations consist of recording central visual acuity and the visual fields for 2/330 white and 1/2000 white. Special attention is paid to “critical” areas, such as the quality of field in

FIG. 5.—Case 4 in Table II, Case 6 in Fig. 9, 49-year-old male. Chromophobe adenoma.

- A. Feb., 1952, before treatment. Visual acuity 20/50 in the left eye and 20/20 in the right.
Treatment Feb.—Oct., 1952.
- B. Oct., 1952, at end of treatment; very slight changes only.
- C. Oct., 1953, first evidence of improvement, 18 months after beginning and one year after completion of treatment. Visual acuity 20/60 in the left eye and 20/20 in the right.
- D. Oct., 1954, further improvement 2 years after completion of treatment.

the temporal paracentral zone where encroachment on fixation is likely. At any time during examination, if further encroachment should take place, the radiotherapist is so advised in order that he may diminish the dosage or frequency of treatment. Should the treatment cause considerable encroachment, it is discontinued and the patient is examined daily until the vision returns to its pre-treatment status, when treatment is again undertaken, perhaps less energetically.

When visual function tends to diminish or barely maintains itself during treatment, examinations are carried out more frequently; in cases in which there is no tendency to a loss or some tendency towards improvement, examinations may be carried out less frequently, for example, after every

FIG. 6.—Case 3 in Table II, Case 13 in Fig. 9, 40-year-old male. Chromophobe adenoma.

- A. Jan., 1951, before treatment. Visual acuity 20/20–1 in the left eye and 20/40–2 in the right. Treatment Jan.–July, 1951.
- B. Aug., 1951. 1 month after completion of treatment. Visual acuity 20/20–1 in the left eye and 20/30 in the right.
- C. Aug., 1952, and Feb., 1953, further improvement. 1 year after completion of treatment. Visual acuity 20/16 in the left eye and 20/20–1 in the right.
- D. Mar., 1954, further improvement 2 years and 8 months after completion of treatment. Visual acuity 20/20 in the left eye and 20/20–1 in the right.
- E. Nov., 1956, maintenance of improvement. 1/2000 field does not extend as far as in 1954, but there are no hemianopic features. Visual acuity 20/20 in each eye.

FIG. 7.—Case 20 in Table II, Case 12 in Fig. 9, 55-year-old male. Chromophobe adenoma.

A. Nov., 1951, before treatment. Visual acuity 1/200 in the left eye and 20/60 in the right.

Treatment Nov., 1951–Apr., 1952.

B. Feb., 1952, improvement during treatment. Visual acuity 4/200 in the left eye and 20/30 in the right.

C. Feb., 1953, 10 months after completion of treatment. Return of paracentral temporal field in each eye. Visual acuity 20/30–1 in the left eye and 20/20–2 in the right.

D. May, 1954, 2 years after completion of treatment. Definite filling out of temporal paracentral field during second year after completion of treatment. Visual acuity 20/25 in the left eye and 20/20–1 in the right.

four or five treatments. When only four or five treatments remain to be given, and if the patient seems to be tolerating the treatment well, the patient does not return until 2 to 4 weeks after completing the course of treatment of 1,000r tumour dose, which is one-third the total dosage. At the discretion

FIG. 8.—Case 16 in Table II, Case 10 in Fig. 9, 52-year-old male. Chromophobe adenoma.
 A. Jan., 1952, before treatment. Visual acuity 20/20 in the left eye and 20/60 in the right. Treatment Jan.–June, 1952.
 B. June, 1952, at end of treatment. Visual acuity 20/30–1 in the left eye and 20/40–1 in the right.
 C. July, 1952, one month after end of treatment. Improvement in quality of right paracentral temporal field. Visual acuity 20/25+ in the left eye and 20/30–1 in the right.
 D. Nov., 1952, further improvement. Visual acuity 20/25–2 in each eye.
 E. May, 1953, improvement 11 months after end of treatment. Visual acuity 20/20–2 in the left eye and 20/25 in the right.
 F. Aug., 1954, further improvement 2 years after end of treatment.
 G. Aug., 1955, improvement 3 years after end of treatment. Visual acuity 20/20–2 in each eye.

of the neuro-surgeon, the patient then returns for one or two more such courses, depending on the response to the treatment and the resultant visual status.

If visual loss continues despite such carefully controlled treatment, surgery should be considered. Occasionally, lack of response is due to a mistaken diagnosis, subsequently discovered by surgery. Lesions responsible for failure of roentgen therapy are apt to be meningioma, pituitary carcinoma, aneurysm, chordoma, or craniopharyngioma. While x-ray therapy may be of some value in several of these conditions, it is insufficient to be relied upon without surgery.

Results of Treatment

Of the forty cases shown in Table II (overleaf), 37 had chromophobe adenomata, two had eosinophilic adenomata, and one showed clinical characteristics of both. There were 31 males and nine females. The average age at which the patient presented himself was 49 years. In general, ophthalmological examinations were made during treatment as outlined above. Thereafter, the patients were asked to return at 2- to 6-month intervals, depending on the case; 2 or 3 years after radiation was completed visits tended to become annual or even less frequent.

In order to evaluate the visual function of the entire eye, it was divided into three "functional areas" called "V", "C", and "P"; "V" stood for central acuity (Snellen), "C" for central visual field, and "P" for peripheral visual field. In order to make a tabular record of progress, I found it necessary to compromise somewhere between clinical judgement and true mathematical values. Therefore, I set up the criteria outlined in Table I to denote changes in visual function in the various functional areas.

TABLE I
CRITERIA FOR EVALUATING VISUAL CHANGES

Category	"V"	"C"	"P"
-	Loss of one or more lines (Snellen)	Definite loss in quality or size of field	Definite loss in quality or size of field
O	No appreciable change or slight improvement	No change or slight improvement	No change or slight improvement
+	Gain of one or two lines (Snellen)	Definite improvement in quality (reduction of visual angle to half in some area) or filling out in some quadrant of field (5°)	Definite improvement in quality (reduction of visual angle to half in some area) or filling out in some quadrant of field (20°)
++	Gain of more than two lines (Snellen)	Return of (1/2000) field in one temporal quadrant	Return of (2/330) field in one temporal quadrant
N	No change possible because visual function is normal (20/20)	No change possible because visual function is normal (1/2000 full)	No change possible because visual function is normal (2/330 full)

TABLE II

Figure No.	Case No.	No. in Fig. 9	Age (yrs)	Sex	Chrom. or Eosin.	Results of Treatment			
						Side	V	C	P
(2)	1	—	50	M	C	R L	N N	+ +	+ +
	2	4	54	M	C	R L	N N	++ ++	++ ++
(6)	3	13	40	M	C	R L	+ N	++ ++	++ N
(5)	4	6	49	M	C	R L	N +	++ ++	N +
	5	—	38	M	C	R L	N +	+ O	+ N
	6	15	40	F	E	R L	+ N	++ O	+ O
	7	1	54	M	C	R L	N N	++ ++	++ ++
(3)	8	—	47	M	C	R L	- O	- -	- -
	9	—	35	M	C	R L	- O	- +	- O
	10	—	55	M	C	R L	O +	O +	O +
	11	14	47	M	C	R L	++ N	+ +	+ N
	12	—	63	M	C	R L	N -	- -	- O
	13	—	35	M	C	R L	- N	- O	- N
	14	16	43	M	C	R L	N +	+ +	N +
	15	—	60	M	C	R L	O ++	++ ++	+ +
(8)	16	10	52	M	C	R L	++ N	++ ++	+ +
	17	—	70	F	C	R L	O ++	+ +	O O
	18	2	32	F	C	R L	+ O	++ ++	+ O
	19	20	47	M	C	R L	N N	++ ++	+ +
(7)	20	12	55	M	C	R L	++ ++	++ ++	++ ++

continued

RESULTS OF TREATMENT IN FORTY CASES

Figure No.	Case No.	No. in Fig. 9	Age (yrs)	Sex	Chrom. or Eosin.	Results of Treatment			
						Side	V	C	P
	21	7	39	M	C	R L	+ O	+ ++	++ +
	22	18	62	F	C	R L	O +	++ ++	O O
	23	—	52	M	C	R L	O +	O +	+ +
	24	—	62	M	C	R L	+ O	N O	O +
	25	—	28	F	C	R L	O O	O O	O O
	26	—	53	M	C	R L	- O	- O	O O
	27	5	68	F	C	R L	+ N	+ O	+ O
	28	—	49	M	C	R L	O O	+ O	O O
	29	8	55	M	C	R L	O O	++ +	+ O
	30	11	54	M	C or E	R L	N ++	+ ++	N +
	31	17	49	F	C	R L	N ++	++ ++	++ ++
	32	—	44	M	C	R L	O -	O O	- O
	33	19	60	F	C	R L	N N	++ ++	N N
(1)	34	—	52	M	E	R L	N N	+ +	N N
	35	—	40	M	C	R L	O O	+ O	O O
(4)	36	9	25	M	C	R L	+ +	++ ++	+ +
	37	—	40	M	C	R L	N N	N +	N N
	38	—	49	M	C	R L	++ +	++ +	N N
	39	3	47	M	C	R L	+ +	+ +	N +
	40	—	54	F	C	R L	++ ++	++ ++	++ ++

Since eighty eyes were involved in the forty cases, Table II was made to evaluate the effect of radiotherapy on the 80×3 , or 240 functional areas concerned.

In order to summarize the results of Table II, Table III was devised. Here, in order to evaluate each of the visual functional areas individually, the "N" category was omitted in the percentage tabulation, since the category "N" denoted normal function to start with, that is, a normal visual acuity of 20/20 or a normal field for 1/2000 white or 2/330 white. Therefore, the percentages in each functional area were based on a total number of 80 minus the number of eyes falling into the "N" category. For example, in the column for "V", since 26 eyes fell into the "N" category, the percentages were based on a total of only 54 eyes, since these were the eyes capable of showing a change for the better. Since 44 of the 240 areas fell into the "N" category, this left a total of 196 functional areas capable of showing improvement by treatment.

TABLE III
RESULTS OF TREATMENT BASED ON 196 FUNCTIONAL AREAS (EXCLUDING "N" CATEGORY), *i.e.* AREAS NORMAL TO START WITH, AND ON 240 FUNCTIONAL AREAS ("N" CATEGORY INCLUDED)

Category	V	C	P	Totals
O	20	14	21	55
+	17	24	23	64
++	11	33	14	58
-	6	7	6	19
Total	54	78	64	196
N	26	2	16	44
Grand Total	80	80	80	240

Basis		196 Functional Areas (N category excluded)	240 Functional Areas (N category included)
Result	Maintained (O)	55 (28.0%)	99 (41.2%)
	Improved (+ and ++)	122 (62.2%)	122 (50.8%)
	Lost (-)	19 (9.6%)	19 (7.9%)

In evaluating the overall effect, it is seen that visual function was maintained or improved in 90.2 per cent. (28.0 + 62.2 per cent.), and lost in 9.6 per cent.). If one considers the maintenance of vision as a satisfactory result, this 90 per cent. compares rather favourably with the 70 per cent. in a series of fifty cases reported by Kerr (1948).

On the other hand, if the "N" category is added to the "O" category to indicate maintenance of vision, and the result is based, therefore, on 240 functional areas, it is seen that vision is maintained in 41.2 per cent. and improved in 50.8 per cent. This accounts for 92 per cent. improved or maintained, and 7.9 per cent. lost.

In keeping with the general excellence of these results, in only four cases was surgery eventually found to be necessary. Of these four patients, two presented themselves with advanced visual loss to start with and proved to have massive lesions at surgery. The other two also had substantial visual loss before radiotherapy and were eventually shown to have large cysts.

At this point it should be remembered that relatively few patients were treated unsuccessfully and then proved on surgical exploration to have a lesion other than a pituitary adenoma. Two proved to have pituitary carcinomata and one a meningioma. Obviously, the inclusion of these few cases would make the above results only slightly less encouraging.

Interval of Time after Radiation when Improvement was Noted

Since the maintenance or improvement of visual function is used as an index of success of treatment or as a guide to subsequent surgery, the time during which visual function may continue to show improvement is of considerable interest and importance. For this study, only those cases were chosen in which good results were found and in which a sufficient number of examinations was made at suitable intervals to indicate how long after completion of treatment improvement continued to take place. Twenty of the forty cases met these criteria. These patients were followed for from 14 to 96 months (average 52). Fig. 9 (overleaf) shows the time intervals of such improvement. The time of detecting improvement in visual function is plotted in relation to the time after which treatment was started and ended. Each vertical column from left to right represents 12 months. Each black horizontal line represents the duration of time during which the patient was under observation. The stippled portion indicates the time during which the patient was under treatment. A bold, white dot indicates the time at which a definite improvement was detected; thus, each white dot represents an "episode of improvement". Two such dots side by side denote a very marked improvement. The total number of dots on a black line merely represents the units of the total improvement in that particular case and not any particular amount of improvement. Thus, if a line shows three dots, each represents one-third of the total improvement in that particular case, however much or little that improvement may have been. When such dots occur in a stippled area it means that improvement occurred at that time during treatment.

In order to show that certain episodes of improvement took place when charted and not much before, a small, white, vertical line was inserted to

indicate that an examination had been made at that time and no further improvement found. For example, in Case 18, a white dot in the fourth year indicates that an episode of improvement took place then. In order to prove that it had not taken place during the third year or even at the end of the second year, there is a small, white, vertical line at the end of the second year and another one at the end of the third year, indicating that examinations had been made at those times and the visual status was no better than it had been during the middle of the second year. Therefore, the "episode of improvement" in the fourth year undoubtedly occurred during that fourth year and not before.

FIG. 9.—Time of improvement related to time of treatment. The cases are arranged in order of duration of treatment (Column 3). The number used in Table II for each patient is shown in Column 2, and the number of the Figure illustrating the patient's visual fields is shown in Column 1.

Where treatment was repeated this was indicated by another area of stippling. Thus, in Case 20, it is seen that treatment was resumed for a period of 2½ months toward the end of the third year. In some cases improvement did not occur until well after treatment had been completed. Thus, in Case 6, treatment was given on and off for 8 months and, 3 months later, the white line indicates that no improvement had yet been found; 4 months later, however, that is 7 months after the completion of treatment or 17 months after the beginning of treatment, definite improvement was noted for the first time; 5 months later, one year after the completion of treatment or 22 months after the beginning of treatment, a marked improvement is represented by a double dot; one year later, that is almost 2 years after the completion of treatment, another marked improvement is represented by a double dot.

In order to obtain a bird's eye view of the time of improvement, one has merely to note the concentration of dots in the boxes representing each year. It is seen that only a small amount of the early improvement was noted

toward the end of treatment while a good deal more was seen during the first 6 months after treatment was completed. Actually, only ten of these twenty selected cases showed some appreciable improvement during or towards the end of treatment, on an average 4 to 6 months after beginning treatment. When improvement did not occur until well after treatment was completed, the average time of such improvement was 5 months after completion of treatment.

In any event, most of the significant early improvement occurred between 6 months and one year after treatment was started, this period being represented by 27 dots or "episodes" of improvement. During the second year, it is seen that improvement continued, as represented by 22 dots, almost comparable to the 27 dots seen in the first year. Granted that some of this improvement may have occurred at some time earlier than indicated, perhaps soon after the previous visit, still there is good evidence that many of these 22 dots occurred more than a year after treatment was completed. Evidence of improvement even later than the second year is shown by the white dots appearing in the third year and fourth years.

In order to evaluate the percentage of improvement during these yearly periods, a slight adjustment was made in adding these dots representing episodes of improvement. Thus, the episode of improvement in Case 20 which occurred directly after treatment during the third year was credited to the first year column, since it did occur directly after treatment, thereby making the total 28 instead of 27. Similarly, the episode of improvement in Case 20 represented in the fifth year is credited to the second year column because the improvement occurred during the second year after the last course of treatment. In Case 14, the episode of improvement represented in the fifth year is credited to the third year because no examination had been made between the second and fifth year and a more conservative evaluation should place this episode of improvement in the third year. Finally, in Case 7, where an episode of improvement is noted during the fourth year, this is again credited to the third year because the patient had not been examined during that time and this episode of improvement was added to those of the third year as a reasonable estimation of greater accuracy. In other words, the above adjustments were made before adding the "episodes of improvement" for each year, thereby giving the following figures: 28 such episodes occurred during the first year, 23 during the second year, nine during the third year, and three during the fourth year. Those of the fifth year have been transferred in the adjustment as indicated above, and the single episode of improvement in the seventh year was discounted because of its solitary occurrence, although this patient showed very definite improvement in visual acuity and field at that time. In terms of percentage and based on a total of 63 episodes of improvement, 44 per cent. of such improvement occurred during the first year, 37 per cent. during the second year, 14 per cent. during the third year, and 5 per cent. during the fourth year.

Buschke (1950) observed that it may take many months or even a year before the total amount of improvement is noted. On the other hand, Kerr (1948) felt that some evidence of improvement should occur within 2 months if surgery is to be avoided. Therefore, it is of considerable interest to note that in the cases I studied improvement did not begin until some months after the completion of treatment, and might then continue for 2, 3, or even 4 years.

Conclusions

It may appear somewhat bold to draw definite conclusions from so small a number of cases. However, in view of the manner in which they were selected and the mode of evaluation, the following conclusions seem justified:

(1) Patients with pituitary adenoma, if not too far advanced or cystic, show excellent responses to radiotherapy. If such cases are properly diagnosed and selected, one may expect as high as 90.2 per cent. of the functional areas to show improvement or maintenance of visual function. Improvement was noted in 62.2 per cent. and maintenance in 28 per cent. If one includes the "N" category together with the "O" category, the results are maintenance in 41.2 per cent., improvement in 50.8 per cent., and vision lost in 7.9 per cent.

Even 28.0 per cent. of maintained vision must not be taken lightly, since the cases selected were not too severely affected to begin with, and, particularly in an older person, such maintenance is indeed a satisfactory result. The value of such maintenance becomes even greater when one considers the additional risks of surgery, however skilled the surgeon.

(2) A slow type of treatment guided by frequent visual examinations has been found quite satisfactory. The frequent examination of the quality of the entire field during treatment leaves little danger of serious, undetected loss. In addition to serving as an index for dosage and frequency of treatment, such examination furnishes the neuro-surgeon with an accurate safety gauge whereby surgery may always be undertaken in plenty of time to avoid serious loss of visual function.

(3) In some cases improvement may occur during treatment (ten out of the twenty cases), but it may not occur until some months after treatment has been completed. While 44 per cent. of improvement occurred during the first year after the beginning of treatment, 37 per cent. occurred during the second year, and a considerable proportion of this 37 per cent. occurred as long as a year after treatment had been completed. Some improvement was demonstrated even during the third and fourth years after treatment had been started, corresponding to $2\frac{1}{2}$ and $3\frac{1}{2}$ years after the end of treatment.

Therefore, when administering radiotherapy for pituitary adenoma, if no serious visual loss threatens the patient during treatment, one should allow at least 4 to 6 months to elapse after the completion of treatment before concluding that no improvement will take place, and at least 2 to 3 years before judging the total amount of improvement.

REFERENCES

- BUSCHKE, F. (1950). *West. J. Surg.*, **58**, 271.
CHAMLIN, M. (1949). *Arch. Ophthal. (Chicago)*, **42**, 126.
——— and DAVIDOFF, L. M. (1950). *Ibid.*, **44**, 53.
——— (1952). *Amer. J. Ophthal.*, **35**, 381.
———, and FEIRING, E. H. (1955). *Ibid.*, **40**, 353.
KERR, H. D. (1948). *Amer. J. Roentgenol.*, **60**, 348.