

Bi-Frontal Stereotactic Tractotomy*

A follow-up study of its effects on 210 patients

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INTRODUCTION

Since 1955 there has been a steady decline in the number of leucotomy operations, particularly of the open standard type introduced into this country in 1941. It has been considered by most authors that the undesirable side-effects caused this decline but no doubt the introduction of ataractic drugs also played its part (Pippard, 1962). Sykes and Tredgold (1964) discussed in detail the literature up to that time and it was felt unnecessary to repeat that survey here. Suffice it to say that from about 1949 various modifications of the standard operation were devised in the hope of diminishing or eliminating undesirable sequelae. Following the publication of a paper on the late social results of pre-frontal leucotomy by Ström-Olsen and Tow (1949) the late Alexander Kennedy (1949) wrote in the correspondence column of the *Lancet*—'The future of this kind of operation (i.e. standard leucotomy) lies in limited and accurately localized sections. The correlation of these with their clinical and neuropathological effects offers a field of study which will occupy us for many years to come'.

Of the modifications discussed by Tredgold only those involving the orbital cortex concern us here. Scoville first introduced orbital cortex undercutting under direct vision in 1949. This was adopted by Tow and Lewin (1953), Knight and Tredgold (1955) and Ström-Olsen and Northfield (1955). In 1959 Knight reported on his own technique of Scoville's incision known as restricted orbital undercutting. A year later he introduced a new stereotactic method which involved the insertion of two rows of four radioactive yttrium seeds (later

changed to two rows of three seeds) on each side into the white matter of the posterior orbital cortex (*substantia innominata*), and his first results of this operation were published in 1964. Since then further communications have appeared, notably his paper in 1969. For technique the original paper should be consulted.

It is with this stereotactic operation that the present study is concerned, being purely a follow-up study on those patients, 210 in all, operated on between June 1961 and January 1968. The object has been to attempt to assess the long-term therapeutic action of this treatment and also to determine the presence or absence of any harmful side-effects, physical, psychological or social, either temporary or permanent. Even following the restricted orbital undercutting Sykes and Tredgold found a 5 per cent risk of behaviour changes and a 16 per cent risk of postoperative epilepsy. From 1961 to 1967 the tractotomy operation was carried out at the Postgraduate Hospital, Hammersmith, but for the past two and a half years the operation has been performed at the Brook General Hospital. A small unit of eight beds has been made available solely for this purpose, so that patients can be investigated both before and after operation. Because of the time factor the great majority of patients have only been seen by us after operation, though eleven were in fact seen before by one of us (R.S.-O.). Since this work started a part-time clinical psychologist has been appointed to test patients before and at varying intervals after operation. His work will be the subject of a separate communication at a later date.

PLAN OF WORK

A total of 210 patients were considered suitable for incorporation in this research,

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divided into four categories. Firstly, those who were interviewed together with their relatives where possible, 150 in all (Group A). Secondly, those who were not able to be seen on account of distance or difficulty in travelling, about whom information was obtained from case records, psychiatrists, or their general practitioners; these numbered 29 in all (Group B). Those who could not be traced, or where very little information was available, numbered 2 (Group C). Lastly, patients who died before or during the period of follow-up study numbered 29 (Group D).

Obviously the information gathered about Group A was the most reliable. Our procedure was as follows. After records had been obtained from the sending hospital or from the referring psychiatrists letters were sent out to patients and their relatives asking them to attend at the Brook Hospital for interview. As a rule relatives or friends were interviewed first, sometimes with both of us being present but more often separately; after that, the patient. These interviews took quite a long time. It should be borne in mind too that a few of the patients and their relatives were not very good informants, but on the whole the scheme worked extremely well.

In some instances the patients were visited in their homes and interviewed together with their relatives by the social worker. Those who were still in-patients were seen by one of us at the various hospitals which were within reasonable distance. Occasionally patients from nearby hospitals would attend with a nurse, who frequently would be able to give valuable information for our study.

The reliability of the information in Group B was sometimes open to question, but generally speaking it enabled us to determine into which category the patient fitted from the point of view of result. This group will be considered separately as will also Group D, the deaths. Group C, of course, has to be omitted from the survey.

PSYCHIATRIC RATINGS

We adopted the same ratings as those of Sykes and Tredgold in order to make our results comparable with theirs:

- Rating I Completely recovered
 II Improved—no treatment required
 —but with slight residual symptoms
 III Improved, but still needing treatment—with persistent symptoms
 IV Unchanged
 V Worse.

We investigated fully the question whether capacity for work or enjoyment of pleasure were affected adversely as a direct result of the operation. As far as ratings were concerned we found it difficult to lay down hard and fast categories, but we adopted the terms 'full', 'partial' and 'none' as far as it was possible from the information obtained. This is based on experience gained in a follow-up study of leucotomized patients by Tow and one of us (R.S-O.).

WORKING CAPACITY

1. *Full*—Ordinary full employment of the sort the patient was used to—up to normal accepted standards (with a fairly liberal interpretation). Mere attendance at his place of work did not count—if he was not up to the job.
2. *Partial*—(a) Part-time or partial employment; (b) Performance of obviously substandard work, even though he was full-time.
3. *Self-occupied*—Equivalent to 'self-amused'. Patients who occupied the time by trifling and ineffectual activities not useful to others.
4. *None*—Those who did nothing.

CAPACITY FOR PLEASURE

1. *Full*—Active enjoyment of entertainment, social activities, reading, music, TV, etc.
2. *None*—Absence of above.
3. *Partial*—Those evenly distributed between 1 and 2.

TOTAL CASE MATERIAL

Of the total series of 210 patients 177 were referred directly from other psychiatric hospitals, the majority coming from those in the South-East Metropolitan Region. The remainder were referred by psychiatric in-patient and out-patient departments of general hospitals, by day hospitals and directly by consultants. The few referred by general practitioners were seen by one of us (R.S-O.) to assess suitability for operation.

TABLE I
Age and sex of the gross total of 210 cases

Age	Male	Female	Total	Percentage
21-30	8	13	21	10
31-40	9	33	42	20
41-50	12	33	45	21
51-60	11	26	37	18
61-70	11	33	44	21
71-80	3	12	15	7
Over 80	1	5	6	3
Total	55	155	210	100

It will be seen that nearly three times as many females (74%) as males (26%) were treated, and that 80% were between the ages of 31 and 70.

THE NATURE AND TREATMENT OF GROUP A

TABLE II shows the age and sex distribution and Table III duration of illness.

In 72% of cases duration of illness was over 5 years.

TABLE II
Age and sex distribution

Ages	Males	Females	Total	Percentage
21-30	2	11	13	9
31-40	5	30	35	23
41-50	8	27	35	23
51-60	7	21	28	19
61-70	6	24	30	20
71-80	—	7	7	5
Over 80	—	2	2	1
Total	28 (19%)	122 (81%)	150	100

TABLE III
Duration of illness

Duration	Total	Percentage
Less than 2 years	3	2
2-5	39	26
6-10	43	29
11-15	24	16
16-20	17	11
Over 20	24	16
Total	150	100

DIAGNOSTIC CATEGORIES

The numbers in seven diagnostic groups are shown in Table VI. Of the recurrent depressions

none had real manic episodes, though in some cases a mild hypomanic colouring was evident between the attacks. This took the form of increased energy, sociability, marked cheerfulness and generally increased tempo in comparison with the depressive phase, features characteristic of the typical cyclothymic temperament.

Involuntary depressions were very few, possibly because this type of patient usually does well with ECT.

The other types of depression included those where the condition was chronic, sometimes associated with obsessive thoughts, mild paranoid ideas and severe hypochondriasis. In all these depression was the outstanding symptom.

Anxiety state included all patients whose main symptoms consisted of anxiety, tension, phobias and panic attacks, somatic symptoms and complaints, neuromuscular hypertension, tachycardia, excessive sweating, tremors and tension headaches. Cases referred as 'neurotic depression' invariably presented with the main symptoms of anxiety and tension coupled with physical symptoms; the depression could be regarded as secondary to their condition, which was often of very long duration.

Obsessional neurosis only included those who fell within the definition given by Aubrey Lewis (1935): 'Whenever a patient complains of some mental experience which is accompanied by a feeling of subjective compulsion so that he does not willingly entertain it, but on the contrary does his utmost to get rid of it, that is an obsession.' All had compulsions.

The five schizophrenics were well established cases, about whom there could be no mistake in the diagnosis. They exhibited bizarre or paranoid delusions, with hallucinations and often impulsive behaviour, coupled with autism, emotional blunting and incongruity of affect and disorder of associative thinking.

The final category included psychopathic behaviour, character disorder and inadequate or hysterical personality with emotional imbalance.

PREVIOUS TREATMENT

All patients referred had received the appropriate treatment for their condition as far as one

could ascertain. Ten had never been in a mental hospital; 58 had had one to three admissions; and 82 four or more. As the duration of illness in 72 per cent of cases was more than five years it was obvious that the vast majority had received a great deal of treatment with either temporary benefit or no effect at all. Chronicity and failure of response to any form of conservative method of therapy were, in fact, the main indications for stereotactic surgery.

All depressives in our series underwent ECT. The number of treatments given in each course varied from 4 to 15 but mostly 6 to 8 were given. 52 patients had more than 4 courses and one actually had 23 courses. All received only temporary benefit.

All 150 patients had received drugs over a prolonged period, tranquillizers, antidepressants, and hypnotics. Of these 78 (52 depressives) showed temporary benefit and 72 were unchanged. One had a course of insulin coma with temporary improvement, 31 (17 depressives) had had at least one course of modified insulin of whom 26 (15 depressives) benefited temporarily.

The information available about psychotherapy was so vague and incomplete that no satisfactory conclusion could be drawn from it. No doubt most patients received psychotherapy, particularly as out-patients, and one patient underwent a course of psycho-analysis.

12 patients had undergone other surgery before tractotomy, 9 leucotomies, 2 orbital undercuttings, and 1 leucotomy plus orbital undercutting. Only 4 had shown temporary improvement, the rest being unchanged.

3 men and 8 women had been seen by R.S.O. before tractotomy, the rest not.

THE FOLLOW-UP OF GROUP A

110 cases were seen by both psychiatrist and social worker, 32 by social worker alone, 8 by psychiatrist alone. The time after the operation is shown in Table IV, the number completely recovered (I) or unchanged (IV) in Table V and the outcome by diagnostic category in Table VI.

Recurrent depression: Figs. 1 and 2 show an analysis of the duration of illness, number and

TABLE IV
Length of follow-up

	Total	Percentage
16 months and less than 2 years	52	34
2 years and less than 3 years	38	25
3 years and less than 4 years	31	21
4 years and less than 5 years	14	9
5 years and less than 6 years	10	7
6 years and less than 7 years	4	3
7 years and less than 8 years	1	1
Total	150	100

TABLE V
Psychiatric ratings at follow-up

Psychiatric ratings	Total	Percentage
I	49	33
II	24	16
III	35	23
IV	41	27
V	1	—
Total	150	—

TABLE VI
Psychiatric ratings and diagnoses

Diagnosis	Psychiatric ratings					Total
	I	II	III	IV	V	
Recurrent depression	20	5	12	8	—	45
Involitional depression	3	2	1	—	—	6
Depression (other types)	8	4	5	7	—	24
Anxiety state	10	9	11	16	—	46
Obsessional neurosis	7	3	3	6	1	20
Schizophrenia	—	—	2	3	—	5
Others	1	1	1	1	—	4
Total	49	24	35	41	1	150

duration of attacks which required hospital treatment, and intervals of normality before operation. Where the interval between attacks was short the patients usually remained in hospital otherwise they were discharged between the attacks.

Involitional depressions: The numbers here are too small for proper assessment. Even so 5 out of 6 did well.

Depression (other types) responded less favourably than the recurrent depressions, which one

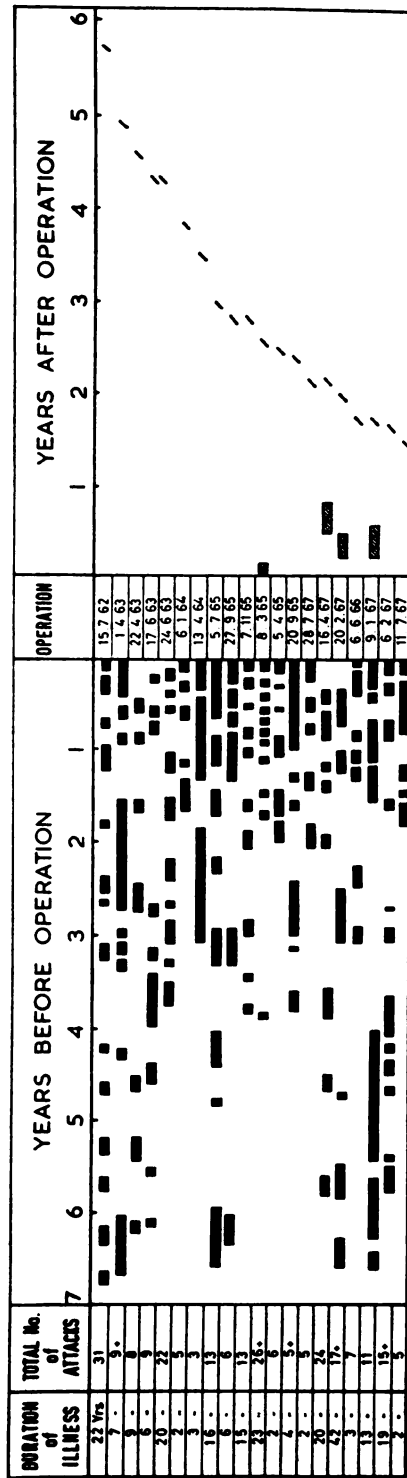


FIG. 1.—Recurrent depressions who reached psychiatric rating I: attacks before and after operation.

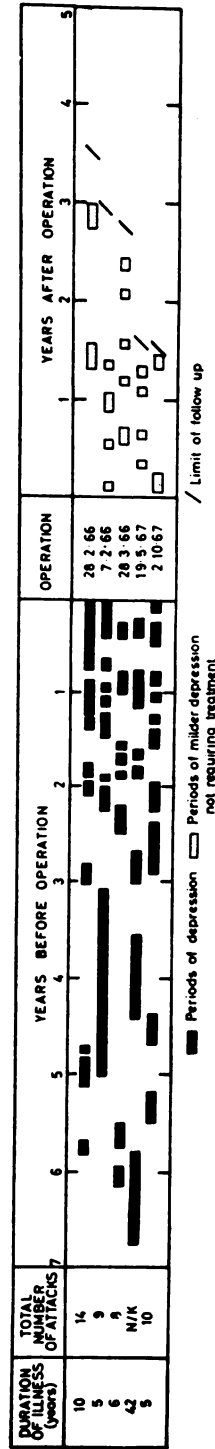


FIG. 2.—Recurrent depressions who reached psychiatric rating II: attacks before and after operation.

might perhaps have expected from the rather mixed symptomatology. The duration of illness was of no significance with regard to outcome. 4 patients in which the duration was between two and five years reached complete recovery (rating I). Similarly, 2 patients of between 16 and 20 years' duration and 2 patients where the duration was over 20 years also reached this rating.

Anxiety states: The outcome here was less good than in the depressives (Table VII).

TABLE VII

Duration of illness	Psychiatric ratings				Total
	I	II	III	IV	
Less than 2 years	—	—	—	—	—
2-5	4	3	2	1	10
6-10	2	—	6	5	13
11-15	1	1	2	4	8
16-20	2	2	—	3	7
Over 20	1	3	1	3	8
Total	10	9	11	16	46

It will be seen that 19 out of 46 reached ratings I and II compared with 42 out of 75 of all depressives. Duration of illness may have some significance in that 7 out of 10 reached rating I and II for those who were ill for 2-5 years, which is somewhat better than the other scores.

Obsessional neurosis: 20 patients were operated on. As it happens, this was the same number as reported by Sykes and Tredgold. In our cases duration of illness made little difference to the final result, as will be seen from Table VIII.

TABLE VIII

Duration of illness	Psychiatric ratings					Total
	I	II	III	IV	V	
Less than 2 years	—	1	—	—	—	1
2-5	1	1	1	—	—	3
6-10	2	—	1	4	—	7
11-15	1	—	1	—	—	2
16-20	1	—	—	1	—	2
Over 20	2	1	—	1	1	5
Total	7	3	3	6	1	20

Of the 20 patients, 10 reached ratings I and II, compared with 6 in the Sykes and Tredgold series, though of course the numbers are too small to be of significance. Two patients with rating IV had had previous leucotomies, one had two modified and a right-sided standard operation, the other had a rostral leucotomy without benefit. In those who reached rating II there was a marked lessening of tension, and although compulsions were still present to some extent the patient showed less concern about them. All these three were free from depression. One patient lost her frigidity. The three patients who reached rating III showed lessening of tension, anxiety and depression but still retained compulsions, albeit of less intensity, and continued to require treatment.

Schizophrenia: Three schizophrenics were unchanged but two showed lessening of tension, aggression and depression due to their delusions and hallucinations, although the latter remained in the main unaltered in content. These two were eventually discharged from hospital and one is attending out-patients from time to time and the other her general practitioner. The duration of illness in these two patients was 9 years and 15 years respectively. Of the others, 2 suffered from schizophrenia simplex and the durations were 8 and 17 years respectively, and the third from schizophrenia engrafted on congenital mental defect, though florid symptoms were present only for 1½ years.

Other conditions: included one folie à deux (paranoid symptoms of 4 years' duration), one paraphrenic (10 years), one behaviour disorder due to traumatic temporal lobe epilepsy (13 years) and a fourth with character disorder, paranoid symptoms and depression (5 years). Of these the folie à deux case, a girl of 23, reached rating I and returned to her occupation as a teacher, married and is living a normal life. The patient with behaviour disorder due to temporal lobe epilepsy who attained rating II was a girl of 32 who had been ill 13 years. She showed a marked decrease in her paranoid symptoms, aggression and hostility. Strangely enough, too, her fits lessened in frequency. The other 2 cases did not do so well, though one did actually attain rating III and was able to resume work although many of her symptoms,

apart from the depression, were still present. The fourth case remained unchanged and is still an in-patient, though there was a marginal diminution of his aggressive symptoms.

Immediate and delayed recovery

The 49 cases who recovered completely were investigated to see whether recovery occurred immediately after operation or was delayed for some months. It was found that 24 patients obtained immediate relief from their symptoms while still in the surgical ward, while the remaining 23 took on an average 4½ months, the extremes being two and ten months, while two did not recover until over a year after operation (Table IX).

TABLE IX
Speed of complete recovery

Diagnosis	Immediate	Delayed	Total
Recurrent depression	13	7	20
Involuntional depression	2	1	3
Depression (other types)	2	6	8
Anxiety state	5	5	10
Obsessional neurosis	2	5	7
Schizophrenia	—	—	—
Others	—	1	1
Total	24	25	49

Effect of operation on symptoms

An isolated symptom or groups of symptoms are very frequently relieved even when the overall picture does not warrant us to regard the patient as recovered. Thus, the relief of tension in obsessionals will often cause considerable subjective easing of distress although the compulsions may still be present. Improvement in depression will result in the lessening of intensity of symptoms in a melancholic patient. Although the operation may not effect a clinical recovery it will reduce the agonising distress of the depressive and make life more bearable and the patient more amenable to conservative methods of treatment. As regards delusions and hallucinations, these remained unchanged in the one paraphrenic, in the schizophrenics and the depressives who failed to improve. It is noticeable that interest, power of concentration and self-confidence improved markedly. One obses-

sional became worse as regards her rituals and compulsions. In addition a chronic anxiety patient developed persistent compulsions one year after operation.

FURTHER SURGICAL TREATMENT

16 of the 150 patients in Group A who remained unchanged (rating IV) after tractotomy underwent further neurosurgery. Their diagnostic categories were as follows: recurrent depression 3, chronic depression 2, anxiety state 7, and obsessional neurosis 4. Seven had an orbital cortex cutting, six a second tractotomy (two in a different hospital). A further two had a repeat tractotomy and a cortical undercutting and finally one patient, an obsessional, had a cingulectomy performed. These operations were carried out 12 to 26 months after failed tractotomy. 7 more of the 16 patients then reached ratings I or II.

CAPACITY FOR WORK AND PLEASURE

It must be noted that many of the patients we were dealing with were not seriously incapacitated before operation. Despite their symptoms some were able to carry on working, albeit with some difficulty and not entirely up to normal standards. This often meant that a wage-earner had a job to return to after operation and did not have the difficulty of finding work and explaining years of absence. This was not so in all cases, obviously, but where it was it may have contributed to their improvement. Housewives were at an advantage in that they had a job to return to in the shape of a house and family. With work we attempted to make the categories applicable to both wage-earners and housewives.

We excluded 14 cases from the ratings; 11 aged 70 or over, 1 physically infirm and 2 because of lack of information.

Before operation the majority of patients (72) were in the partial group, and afterwards 72 had attained full working capacity, 24 of them from the lowest groups.

To the left of the broken line in Table X are 6 cases whose work ratings deteriorated, and who need to be explained. 5 were rating IV, and of these 2 became long-term in-patients and

TABLE X
Changes in work ratings

Post-operative ratings		Pre-operative ratings			
		1 Full	2 Partial	3 Self- occ.	4 None
1 Full	72	—	47	9	15
2 Partial	31	—	20	5	6
3 Self-occupied	18	—	3	13	2
4 None	15	—	2	1	12
Total	136	1	72	28	35

In most cases where the patient was a long-term in-patient his/her rating was classed as none or self-occupied.

the other 3 went home but had received no benefit from operation. In these cases it seems reasonable to assume that the deterioration in work ratings was associated with their original and continuing abnormal mental state and in no way due to operation.

The sixth was a 59-year-old American who reached rating II but could not get work, partly because of age and nationality but largely because he suffered from chronic bronchitis and emphysema.

TABLE XI
Relation of psychiatric and work ratings

Post-operative work ratings	Psychiatric ratings					Total
	I	II	III	IV	V	
1 Full	40	16	14	2	—	72
2 Partial	1	4	13	13	—	31
3 Self-occupied	—	1	6	11	—	18
4 None	—	—	—	14	1	15
Total	41	21	33	40	1	136

There was a highly significant relationship between work and psychiatric ratings at interview (Table XI).

The one case who reached a partial work rating but a psychiatric rating II was a rather immature, over-dependent woman who, even prior to the onset of her illness and although

married with a home to look after, had not done all her own housework but had taken a line of least resistance and allowed her mother who lived with them to do a substantial part of it. The one case classed self-occupied and rating II was the 58-year-old American already mentioned.

TABLE XII
Changes in pleasure ratings

Post-operative ratings		Pre-operative ratings		
		1 Full	2 Partial	3 None
1 Full	74	—	27	47
2 Partial	32	—	14	18
3 None	30	—	2	28
Total	136	—	43	93

The capacity for enjoying leisure was in all cases impaired before operation. The vast improvement after operation is well illustrated by Table XII.

The 2 cases to the left of the broken line with deterioration in pleasure rating also showed deterioration in work rating, showed no improvement in symptoms and were in-patients at follow-up interview. They were included in the earlier discussion of work ratings.

In conclusion we can say that during the course of our study it became obvious that among all patients who reached psychiatric ratings I and II there was not a single instance in which capacity for work or enjoyment of pleasure were adversely affected. In those who had ratings of only III or IV any impairment was undoubtedly due to their original illness. Even among them we discovered two patients in category IV whose working capacity had greatly improved although their psychiatric symptoms had not been relieved. The work and pleasure ratings can perhaps be regarded as reflecting social recovery; if so, these results are very satisfactory.

POST-OPERATIVE COMPLICATIONS AND BEHAVIOURAL CHANGES

The most striking feature of this part of the investigation was the almost complete absence

of symptoms of serious personality damage such as were met with in the post-leucotomy syndrome of former times.

In follow-up studies of standard leucotomy the patients' relatives or friends used to volunteer information on this topic without prompting. In fact, complaints about the patients' behaviour were common. Typical remarks then were: 'She often embarrasses us, but it is lovely to think she is so well' and 'For her this operation has been a miracle, but we wish we had not got to live with her' (Ström-Olsen 1946). In the present series, except in 3 cases, we had no spontaneous complaints from the patient or relatives and information had to be obtained by careful questioning. It soon became apparent that gross behaviour defects were completely absent. It was of considerable importance, however, to discover what, if any, even minor undesirable sequelae there were to the operation.

In the first instance there were after-effects which could be regarded as *physiological* (physical) in nature. Thus, tiredness and lethargy were common temporary symptoms lasting for up to three months. In 25 Group A patients (10 rated I or II) some degree of tiredness had persisted and was present at the time of interview but it was not sufficient to interfere with work or daily routine, although one female aged 53 complained of sleeping during the day at times. Some of the patients rated III or IV were having tranquilizers which may have been a contributory factor. Weight increase occurred in 13 patients, generally of the nature of 9.5–12.7 kg. (1½ to 2 stones) but one did put on 25.4 kg. (4 stone). One patient complained of persistent headaches, another woman lost her sense of smell completely, and one assumes the surgical lesion may have affected the olfactory tract. There were no instances of urinary incontinence.

21 Group A patients developed some post-operative *behavioural* and *psychological* changes, which were lasting and troublesome in 4, but minor and trivial in 17.

Of the 4 serious cases one, a woman aged 68 who lived in an old people's home, became very irritable, spiteful and aggressive. She would strike or scratch other residents and staff for little or no apparent reason. She had

never shown these traits before. Here one must bear in mind her age, her physical disability (arthritis) and the fact that she was no longer able to live at home. Two women, one married aged 30 and the other single aged 27, developed excessive sexual demands, and both eventually became promiscuous; the husband of the former divorced her. Another woman became hedonistic, lacking in inhibition, overactive, and had a tendency to neglect her home because of her pleasure-seeking activities, although she held down a part-time job as a waitress very well. In this case one suspects a swing to mild hypomanic behaviour.

The commonest of the minor symptoms were irritability, outspokenness and volubility, which were not troublesome and did not noticeably affect family or social relationships (11 cases). Three patients stated that they were now smoking excessively. One female patient complained of some difficulty in remembering. She now found she had to make out shopping lists and write down various appointments, whereas before she could remember these quite well. Another woman complained of difficulty in concentrating and could not find the right words to express herself, as she said: 'I have tried to overcome this by explaining these in much smaller words, as I cannot remember directly descriptive words'. This difficulty was not present before the operation. In another case the husband of a woman aged 43 years complained that she had developed frigidity since tractotomy.

It is to be noted that we have not included in this section those patients who had benefited from being a little less inhibited or more outspoken. For example, those who were docile and self-effacing were now able to assert themselves normally.

As far as the occurrence of intellectual impairment is concerned, with the possible exception of the two cases referred to above none was evident at interview nor mentioned by relatives or friends. Foulds examined 24 patients up to twelve months after standard orbital undercutting (Scoville type), an operation more extensive than tractotomy, with a series of psychometric tests. The outstanding features of his results were their constancy and the absence

of any sign of intellectual deterioration (see Ström-Olsen and Northfield, 1955). However, as stated above, psychometric testing before and after tractotomy is being undertaken as a separate investigation by a clinical psychologist.

In summary, none of the patients showed gross personality or behavioural changes. 4 out of 150 (3 per cent) exhibited some lasting and troublesome sequelae. 17 (11 per cent) displayed minor or insignificant symptoms which were of little practical importance, whereas 129 (86 per cent) showed no undesirable symptoms at all.

POST-OPERATIVE EPILEPSY

A careful analysis was undertaken of patients who had epileptic attacks following operation.

(a) 4 cases where epilepsy was present before operation: one patient with severe anxiety neurosis had petit mal both before and after; one who suffered from petit mal attacks before operation had much less frequent attacks afterwards, while one with behaviour disorder due to temporal lobe epilepsy (major and minor attacks) post operatively for one year and ten months had only had petit mal attacks. The fourth, a chronic depressive, who had a 2½ year's history of epileptic attacks before operation continued to have them afterwards but they were fairly well controlled by anti-convulsant therapy.

(b) 3 cases all had one or more fits in 1-4 days after operation and none since (one of them Jacksonian in nature). All of them had been on large doses of barbiturates, with or without phenothiazines, prior to operation. In our opinion the fits can reasonably be regarded as being precipitated by drug withdrawal and operation.

(c) One woman with recurrent depression developed epilepsy six months after operation and up to the time of follow-up has had seven further fits. After being admitted to hospital for investigation no definite lesion could be found and she was given anti-convulsants.

(d) two patients who were consistently taking largactil both before and after tractotomy: a woman aged 31 years was taking 800 mg. chlorpromazine daily and had a fit two months after operation, followed by four further fits

during the succeeding six months. As far as we know the attacks stopped after the cessation of chlorpromazine therapy. A male schizophrenic, on chlorpromazine and with marked orolinguobuccal dyskinesia, had one fit eighteen months after tractotomy, but has had none since. The danger of chlorpromazine after leucotomy has been demonstrated by Liddell and Retterstøl (1957). They reported one death from status epilepticus among 7 patients who developed major epilepsy and 6 patients in whom the EEG showed an epileptic pattern.

Lomas *et al.* (1955) suggested chlorpromazine had epileptogenic properties which might lead to fits in susceptible people. Merlis (1955) found epileptic EEG patterns greatly accentuated by chlorpromazine.

To summarize, it may be claimed that at the most one patient had persistent epileptic attacks following tractotomy. In two others the attacks were probably due to prolonged administration of large doses of chlorpromazine.

RELAPSES

23 patients who had at some time after operation attained rating of I or II relapsed, i.e. came under treatment again, but 12 of them had regained their original psychiatric grading at the time of interview. These relapses occurred against a total of 84 who reached ratings I or II at optimum, leaving therefore 61 patients with this level of recovery who never had a relapse.

18 of the relapses occurred within 12 months the remaining five between 1 and 2½ years. The permanent relapses appeared to be significantly higher in the anxiety states than in the other conditions, though the figures are too small for any firm conclusions to be drawn (Table XIII).

For the 12 who recovered following relapse we tried to assess whether their recovery could be regarded as significant. This proved difficult especially in the recurrent depressions. The interval between the end of the last relapse and the time of the follow-up varied between 7 months and 2½ years. Nine out of the 12 were seen between one and two years after relapse. 6 of these were not recurrent depressions and the length of time was considered significant.

TABLE XIII

Fate of all cases recovered or with only slight symptoms

Diagnosis	Those who did not relapse	Those who did relapse	Total
Recurrent depression	20	7 (5)	27
Involuntional depression	3	2 (2)	5
Depression (other types)	10	2 (2)	12
Anxiety state	18	8 (1)	26
Obsessional neurosis	8	4 (2)	12
Schizophrenia	—	—	—
Other	2	—	2
Total	61	23 (12)	84

The figures in brackets indicate the number of patients who at last interview had regained their old rating.

The remaining 3 were recurrent depressions and had to be assessed carefully:

Case No. 155

Four months after operation this patient had one relapse precipitated by his wife's illness and admission to hospital. This attack was much milder than those before operation, and up to the time of interview he had been symptom-free for 14 months. Prior to operation the interval between attacks was usually about three or four months.

Case No. 159

This patient had one relapse four months after operation, again a very much milder attack, then 18 months' freedom from depression up to the time of interview. The intervals of good health before operation were on average about eight or nine months.

Case No. 164

This patient had one very mild relapse seven months after operation and was then free from depression for 16 months up to interview. The intervals between attacks before operation varied from only a few weeks to five months.

It is now reasonable to assume that because post-operatively they had been free from depression for considerably longer than was ever previously the case recovery from relapse would probably be permanent in these cases.

FOLLOW-UP GROUP B

29 patients were not seen by either of us and although we obtained as much written information as possible we did not regard it as reliable enough to be included in the investigation. For what it is worth, however, 10 out of the 29 apparently reached ratings I or II. Little information was available about undesirable sequelae, including epilepsy.

FOLLOW-UP OF GROUP D—THE 29 DEATHS

The immediate post-operative mortality was nil. In Sykes and Tredgold's series (orbital undercutting) it was 1.5 per cent and in that of Tooth and Newton (standard leucotomy) 4 per cent.

20 of the dead were between the ages of 62 and 86. 10 died between two and ten months after operation, 3 from heart disease, 2 from cerebral thrombosis, 4 from pneumonia, and 1 committed suicide. If we exclude the suicide it could possibly be argued that the operation, which lasts up to 2½ hours, might have been contributory to the cause of death of some of these 9 patients, all of whom were elderly. However, careful perusal of the clinical records did not lend support to this view. The remaining 19 patients died from one to six years after operation, 9 from cardiovascular disorders, 2 from senility, 2 from malignant disease, 3 from pneumonia, and in addition there were 2 accidental deaths and 1 suicide. None of these patients were seen by us and although we were able to obtain some information from hospital records, and in some instances from general practitioners and relatives, the assessment of therapeutic results from tractotomy was only of limited value. However, one woman, aged 72, gave a history of epileptic fits which occurred nine months after operation and which could probably be attributed to it. Bearing in mind the above reservation we nevertheless thought it useful to record that of these 19 patients 9 depressives apparently reached ratings I or II.

DISCUSSION

The recent reports by Post, Linford Rees and Schurr (1968), Kelly, Walter and Sargent (1966) and Marks, Birley and Gelder (1966) have clearly demonstrated that the neuro-surgical treatment of chronic psychiatric disorder particularly of depressions, anxiety states and obsessional neurosis, has come to stay. The main argument against the techniques used up to now is the unnecessary destruction of brain tissue before the target area is reached. Admittedly, personality changes after the modified operations are considerably fewer than those following the standard operation of Freeman and Watts (Pippard, 1955) but the stereotactic method was first introduced in order to obviate even these sequelae. This was first done by Spiegel *et al.* (1947). In 1956 they published a follow-up study of 77 cases treated by thalamotomy and by combined frontal and thalamic lesions. They claimed successes in half their cases, but this method does not seem to have been taken up.

Techniques involving thermo-lesions were reported by Leksell (1949 and 1957). Grantham and Spurling (1953) described a stereotactic method with electrocoagulation by which they were able to make lesions on the medial ventral and dorsal ventral quadrant of the prefrontal area, which resulted in the destruction of pathways from the middle and orbital surfaces of the prefrontal lobe. This technique was used for the relief of pain in 51 patients with considerable success. They asserted that no personality changes resulted, but gave no details. There was one death from operation.

Ultra-sound was used by Lindström (1954), who employed this method successfully for the relief of intractable pain chiefly in patients suffering from cancer, but the technique did not appear to be accurate enough for general use in psychiatric conditions.

One of the most important recent studies on stereotactic thermo-lesions in mental disorder has been carried out by Torsten Herner (1961). The technique used was that of Leksell. The insulated electrodes were introduced lateral to and 6-7 millimetres posterior to the tips of the anterior horn (the ventricles having previously been filled with air) so as to interrupt the fronto-

thalamic radiation. In a series of 116 mixed cases he reported good results in 34 per cent, fair in 45 per cent and poor in 21 per cent. The mode of evaluation of their results, however, makes a comparison with our cases rather difficult except as far as the recoveries are concerned. As regards mortality from the stereotactic methods Herner had none, whereas Spiegel had 2.2 per cent. In Herner's cases 3.4 per cent developed epilepsy. He reported personality changes in 67 per cent of the non-schizophrenic patients. According to him these changes occurred in the emotional, volitional and intellectual spheres and were mild and transient. He mentions, however, that in a small number of patients there were serious side-effects and in three of these there was anti-social behaviour and conflict with the law.

A comparison between our results and those of Sykes and Tredgold (Table XIV) shows that the recovery rate is slightly higher in our series whereas they had rather fewer failures.

TABLE XIV

Recovery rating	Sykes and Tredgold (Orbital Undercut Series)	Our Group A (less 32 not seen by psychiatrist)
I	58 (28%)	36 (30%)
II	48 (24%)	21 (18%)
III	68 (33%)	27 (23%)
IV	29 (14%)	33 (28%)
V	2 (1%)	1 (1%)
Total	205	118

Cortical undercutting is an open operation carried out under direct vision. With the stereotactic technique, owing to variations in the shape of the skull and brain, there are possibilities that minor inaccuracies may arise in the placement of the yttrium seeds in the target area if one relies solely on guidance from bony landmarks. Mr. Knight informs me that it may be possible to improve the accuracy of the lesion by minor modifications. In cases where a subsequent cortical undercutting operation was performed it was seen that there was a zone of white matter a few millimetres wide lying unaffected between the inner border of the lesion and the cortex of the inner aspect of the lobe. He suggests, therefore, that a target point 1.4 centimetres from the midline is too far lateral in the brain and that the lesions should have been directed further medially. This may certainly explain the disappointing results in some of our cases, for instance, why

some recurrent depressions made a complete recovery whereas others with very similar symptoms showed only slight improvement or none at all. This has also been confirmed in the post-mortem examinations carried out by Dr. Corsellis in 8 of the elderly patients who died. In 4 of them where the position of the seeds was accurate they recovered or improved but in 4 cases whose illness was unchanged the seeds were somewhat too far lateral on one side or both and also too far forward, as the needle had not been inserted to the full depth owing to cerebral atrophy. Knight now employs air encephalography to help in target selection and he has changed the target in the antero-posterior view from a point 1.4 centimetres from the midline which, allowing for radio-activity and the magnification factor, should bring the lesion to within one centimetre midline, and he is now using a target point one centimetre from the midline which would bring the lesion to 0.6 centimetres from that line. This should decrease the chance that fibres occasionally continue to traverse an undestroyed zone medial to the target. In the lateral view he no longer restricts the depth of implantation in cases of cerebral atrophy but goes for the full target depth.

In our opinion the future of all neurosurgery in psychiatry will lie in the development and improvement of stereotactic techniques in order to reduce the post-operative undesirable sequelae. With all other methods there is an unnecessary destruction of brain tissue; by avoiding this one may be able to reassure the patient that undesirable after-effects will not occur. The present investigation reveals that there were no demonstrable behavioural changes, even trivial ones, in 86 per cent of patients. 11.4 per cent displayed minor or insignificant symptoms whilst in only 2.6 per cent were there moderate or troublesome sequelae. None exhibited a gross frontal lobe syndrome at any time. It is possible that future refinements in techniques may reduce even this small figure of undesirable symptoms.

Disregarding the three patients who had non-recurring fits up to four days after operation, there was only one patient out of 150 who developed persistent epilepsy which could be ascribed to the operation. Post-operative epilepsy, therefore, occurred in less than 1 per cent of this series, compared with 16 per cent recorded by Sykes and Tredgold.

SUMMARY

1. 210 patients with long-standing apparently intractable psychiatric illnesses who had undergone the operation of bi-frontal stereotactic

tractotomy of the orbital cortex by the use of radioactive yttrium 90 seeds were studied. 150 patients (Group A) together with their relatives and friends were interviewed personally by the psychiatrist and social worker. Information about a further 29 was obtained from other psychiatrists, general practitioners, relatives and a perusal of the relevant clinical records.

2. Of the 150 A cases 49 (33 per cent) recovered completely from their illness and a further 24 (16 per cent) only had minor residual symptoms and required no further treatment, making a total of 49 per cent. A further 35 (23 per cent) improved but still needed treatment, with persistent symptoms. 41 (27 per cent) were unchanged, and one patient was worse.

3. The best results were obtained in the depressions, both recurrent and other forms (56 per cent recovered and much improved). Good results were also obtained in obsessional neurosis (50 per cent recovered and improved). In anxiety states the corresponding figure was 41 per cent. None of the schizophrenic patients did well.

4. No patient showed a gross frontal lobe syndrome post-operatively. In 4 out of the 150 (2.6 per cent) there were some moderate and lasting sequelae. 17 (11.4 per cent) displayed minor and trivial symptoms which were of no practical importance, whereas in 129 (86 per cent) there were no demonstrable personality changes whatsoever. Working capacity and normal enjoyment of pleasure were not affected in any patient.

5. Mortality due to operation was nil.

6. The incidence of permanent epilepsy due to the operation was less than 1 per cent.

7. Of all forms of leucotomy operation stereotactic tractotomy is the one which avoids unnecessary destruction of brain tissue between the cortex and the target area, and it is suggested that further research in this field, with the *substantia innominata* as a target area, is well worthwhile.

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REFERENCES

- GRANTHAM, E. G., and SPURLING, R. G. (1953). 'Selective lobotomy in the treatment of intractable pain.' *Annals of Surgery*, **137**, 602-8.
- HERNER, T. (1961). 'Treatment of mental disorders with frontal stereotaxic thermo-lesions.' *Acta Psychiatrica Supplement* **158**, 140 pp.
- KELLY, D. H. W., WALTER, C. J. S., and SARGANT, W. (1966). 'Modified leucotomy assessed by forearm blood flow and other measurements.' *British Journal of Psychiatry*, **112**, 871-81.
- KENNEDY, A. (1949). Correspondence. *Lancet*, **i**, 242.
- KNIGHT, G. C. (1964). 'The orbital cortex as an objective in the surgical treatment of mental illness. The development of the stereotactic approach.' *British Journal of Surgery*, **51**, 114-24.
- (1965). 'Stereotactic tractotomy in the surgical treatment of mental illness.' *Journal of Neurology, Neurosurgery and Psychiatry*, **28**, 304-10.
- (1969). 'Stereotactic surgery for the relief of suicidal and severe depression and intractable psychoneurosis.' (21st Alex Simpson-Smith Memorial Lecture.) *Postgraduate Medical Journal*, **45**, 1-13.
- (1969). 'Bi-frontal stereotactic tractotomy.' *British Journal of Psychiatry*, **115**, 257-66.
- , and TREDGOLD, R. F. (1955). 'Orbital leucotomy—a review of 52 cases.' *Lancet*, **i**, 981-5.
- LEKSELL, L. (1949). 'A stereotaxic apparatus for intracerebral surgery.' *Acta Chirurgica Scandinavica*, **99**, 229-33.
- (1957). 'Gezielte Hirn Operationen' in *Handbuch der Neurochirurgie*, edited by H. Olivecrona and W. Tönnis. Berlin—Göttingen—Heidelberg VI, 178-99.
- LEWIS, A. (1935) *Proceedings of the Royal Society of Medicine*, **29**, 325.
- LIDDELL, D. W., and RETTERSTÖL, N. (1957). 'The occurrence of epileptic fits in leucotomised patients receiving chlorpromazine therapy.' *Journal of Neurology, Neurosurgery and Psychiatry*, **20**, 105-7.
- LINDSTRÖM, P. A. (1954). 'Prefrontal ultrasonic radiation—a substitute for lobotomy.' *Archives of Neurology*, **72**, 399-425.
- LOMAS, J., BOARDMAN, R. H., and MARKOWE, M. (1955). 'Complications of chlorpromazine therapy in 800 mental hospital patients.' *Lancet*, **i**, 144-7.
- MARKS, I. M., BIRLEY, J. L. T., and GELDER, M. G. (1966). 'Modified leucotomy in severe agoraphobia. A controlled serial inquiry.' *British Journal of Psychiatry*, **112**, 757-69.
- MERLIS, S. (1955). In *Chlorpromazine and Mental Health*. Proceedings of symposium held under auspices of Smith, Kline and French Laboratories—Kempton, Philadelphia and London. 60.
- PIPPARD, J. (1955). 'Personality changes after a rostral leucotomy: a comparison with standard prefrontal leucotomy.' *Journal of Mental Science*, **101**, 774-87.
- (1962). 'Leucotomy in Britain today.' *Journal of Mental Science*, **108**, 249-55.
- POST, F., REES, W. L., and SCHURR, P. H. (1968). 'An evaluation of bimedial leucotomy.' *British Journal of Psychiatry*, **114**, 1223-46.
- SCOVILLE, W. B. (1949). 'Orbital cortex undercutting.' *Journal of Neurosurgery*, **6**, 65-9.
- SPIEGEL, E. A., WYCIS, H. T., MARKS, M., and LEE, A. J. (1947). 'Stereotaxic apparatus for operations in the human brain.' *Science*, **106**, 349-50.
- , —, FREED, H., and ORCHINIK, C. (1956). 'A follow-up study of patients treated by thalamotomy and by combined frontal and thalamic lesions.' *Journal of Nervous and Mental Diseases*, **124**, 399-404.
- STRÖM-OLSEN, R. (1946) 'Prefrontal leucotomy, with reference to indications and results.' *Proceedings of the Royal Society of Medicine*, **39**, 443-4.
- , and TOW, P. M. (1949). 'Late social results of prefrontal leucotomy.' *Lancet*, **i**, 87-90.
- , and NORTHFIELD, D. W. C. (1955). 'Orbital cortex undercutting.' *Lancet*, **ii**, 986-91.
- SYKES, M. K., and TREDGOLD, R. F. (1964). 'Restricted orbital undercutting. A study of its effects on 350 patients over the ten years 1951-1960.' *British Journal of Psychiatry*, **110**, 609-40.
- TOOTH, G. C., and NEWTON, M. P. (1961). *Leucotomy in England and Wales 1942-1954*. London: HMSO.
- TOW, P. M., and LEWIN, W. (1953). 'Orbital leucotomy.' *Lancet*, **i**, 644-9.

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