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RADIATION THERAPY OF MENINGIOMAS*

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MENINGIOMAS are among the more common tumors originating within the cranium. They account for 14.3 to 19 per cent of primary intracranial neoplasms.[14] Meningiomas are usually slow-growing, circumscribed lesions, which are often resectable. However, about 11 per cent of presumably completely extirpated tumors recur.[11] The question arises as to whether irradiation can reduce the recurrence rate of incompletely removed lesions.

Many investigators have stated that ionizing radiation is ineffective in the treatment of meningiomas.[4,6,13] McWhirter[10] reported that approximately 43 per cent of meningiomas were radiosensitive, especially those exhibiting extensive hyperostosis, a cerebral blood supply, and a multilobular form. More recently, King *et al.*[9] urged radiation treatment of incompletely removed meningiomas, especially angioblastic or sarcomatous types. Bouchard[2] advocates irradiation of meningeal tumors that are histologically malignant or clinically invasive. Because of such conflicting opinions we undertook an evaluation of the effect of radiation therapy in patients with meningiomas treated at the University of California, San Francisco (UCSF), from 1942 through 1972.

MATERIAL

The records of all patients in whom the diagnosis of meningioma was made from 1942 through 1972 were reviewed. Meningiomas constituted approximately 20 per cent of all intracranial neoplasms seen during the study period. In each case the pathological material was re-examined by one of us (J.J.T.) and the lesion classified according to the predominant cell type and pattern (Table 1), using the criteria of Rubenstein and Russell.[11,12] The majority of the lesions were transitional meningiomas (49 per cent) or syncytial meningiomas (33 per cent). We are in the process of reviewing and reclassifying these lesions according to criteria suggested by Boldrey.[1]

Most meningiomas occurred in the fifth or sixth decade of life. However, a wide

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TABLE I

HISTOLOGICAL TYPE

Syncytial (meningotheliomatous)	72
Transitional (psammomatous)	106
Fibroblastic	18
Angioblastic	9
Meningeal sarcoma	5
Malignant meningioma	3
Total	213

range of ages was represented, the youngest patient being 6 years old and the oldest 82 years old at the time of diagnosis. Only 6 per cent of all patients with meningiomas were between 6 and 19 years of age. The majority of the lesions arose in the parasagittal-falx region, the cerebral convexity, or the sphenoid ridge; this incidence is comparable to that experienced by other investigators (Table II).

Of 213 patients (143 female and 70 male), who had meningioma, there were 10 in whom the tumor was discovered incidentally at autopsy and 15 who died during the immediate postoperative period. These 25 were excluded from our evaluation. The remaining 188 patients were treated by surgery with or without irradiation and are the basis of the following analysis.

TREATMENT

SURGERY

Total removal of the meningioma was effected whenever possible. When removal was thought to have been complete, no further therapy was given. If complete removal was not possible, there was removal of the maximum amount of tumor consistent with minimal damage from the operative procedure. In some instances incomplete removal was followed by irradiation. Whether radiation therapy was given depended upon the belief of the neurosurgeon regarding its effectiveness for a particular patient.

IRRADIATION

Until about 1950, orthovoltage equipment was usually used for radiation therapy, and the tumor dose was 3,000 to 4,000 rads. Since 1950, most patients have been treated with megavoltage irradiation using total doses of 4,500 to 5,500 rads, with daily increments of 180 rads given over a period of about $5\frac{1}{2}$ weeks.

RESULTS

Eighty-four patients (44 per cent) were treated by "total" surgical removal of the meningioma (Table III). None of them re-

TABLE II

DISTRIBUTION OF INTRACRANIAL MENINGIOMAS ACCORDING TO SITE

Site	Cushing and Eisenhardt[3]	Holub[8]	Earle and Richany[5]	Gautier-Smith[7]	Present Series
Parasagittal-falx	72	95	65	213	52
Convexity	54	74	61	315	42
Sphenoid ridge	53	49	56	124	59
Posterior fossa	23	18	18	57	25
Interventricular	6	7	4	14	4
Peritorcular	12	13	0	20	0
Intraorbital	1	1	0	9	0
Suprasellar	28	21	11	21	19
Temporal fossa	8	0	0	0	0
Olfactory groove	0	0	24	0	11
Diffuse	0	0	0	0	1
Other	0	0	4	0	0
Total	257	278	243	773	213

Table III

TOTAL SURGICAL RESECTION—WITHOUT IRRADIATION (84)

Interval Post Surgery (years)	Alive and Well	Died of Intercurrent Disease (no recurrence)
≤5	31	4
> 5–10	20	6
>10–20	7	3
>20	12	1
Total	70	14

Table IV

SUBTOTAL SURGICAL RESECTION—WITHOUT IRRADIATION (58)

Interval Post Surgery (years)	Alive and Well	Died of Intercurrent Disease (no recurrence)	Recurrence
≤5	9	0	27
> 5–10	2	1	9
>10–20	0	1	7
>20	1	1	0
Total	12	3	43

ceived postoperative irradiation. Fifty-eight per cent of these 84 patients have been observed for 6 years or longer and 27 per cent for at least 11 years. There has been no recurrence of a meningioma in this group of 84 patients.

Of the remaining 104 patients, 58 underwent subtotal removal of the tumor but did not receive postoperative irradiation (Table IV). The recurrence rate in these patients was 74 per cent. Sixteen patients with recurrence were subsequently irradiated (Table V): 7 are alive and well (1 to 9 years after radiation therapy), 6 died from the meningioma (1 to 11 years postirradiation), 2 died of intercurrent disease (8 and 18 years postirradiation), and 1 is alive with known persistence of the disease. The other 27 patients with recurrence were subjected to a second attempt at surgical removal of the lesion without irradiation: 5 are alive without further recurrence, 5 are alive with recurrence (1 to 19 years after reoperation), and 17 died from meningioma (1 to 18 years after reoperation).

Thirty-four patients underwent subtotal resection of tumor followed, as soon as the incision was healed, by irradiation (Table VI). There was a 29 per cent (10 of 34 patients) recurrence rate, with over half of the recurrences appearing within 5 years. Two patients were considered by us to have had inadequate irradiation; *i.e.*, a tumor dose of less than 5,000 rads. Of the 22 patients without recurrence, 14 have been observed 6 years or more and 10 for 11 to 30 years. Of the 10 patients who developed a recurrence, 2 are living after reoperation and the other 8 are dead because of the recurrence.

The remaining 12 patients underwent biopsy only or partial resection of tumor with postoperative irradiation and planned

Table V

TREATMENT OF RECURRENCES FOLLOWING SUBTOTAL RESECTION (43)

	Radiation Therapy	Surgery
Alive and well	7 (1–9 years*)	5 (1–23 years†)
Alive with the disease	1 (2 years)	5 (1–19 years)
Died (intercurrent disease)	2 (8 and 18 years)	0
Died of the disease	6 (1–11 years)	17 (1–18 years)
Total	16	27

* Period post therapy.
† Period postoperative.

TABLE VI

SUBTOTAL SURGICAL RESECTION WITH POSTOPERATIVE IRRADIATION (34)

Interval Post Surgery (years)	Alive and Well	Died of Intercurrent Disease (no recurrence)	Recurrence
≤5	8	2	6
> 5–10	4	0	1
>10–20	4	0	3
>20	6	0	0
Total	22	2	10

reoperation (Table VII). In each case, at the time of the initial operation, the tumor was considered not totally resectable, usually because of excessive vascularity. At the Cushing's Society Meeting in 1965 Boldrey advocated giving radiation therapy to decrease the vascularity of the tumor and assist in removal at reoperation. The tumor dose was 5,000 to 5,500 rads delivered in 5½ to 6 weeks. Generally, an interval of about 6 months was allowed between irradiation and reoperation. Eight patients subsequently underwent total tumor resection; 7 are alive and well with no recurrence from 4 to 13 years after operation. In the other 4 patients, total resection of the meningioma remained impossible; 1 of these patients has subsequently died of the disease.

The treatment groups are classified in Table VIII according to histologic appearance of the tumor and treatment. The number of recurrences is shown in parentheses. No correlation is evident between histologic type and whether total resection was performed. Similarly, no correlation exists between histologic type and recurrence rate. It is possible that correlation may be found when the lesions are reclassified according to Boldrey's schema.

DISCUSSION

The natural course of a meningioma is long and variable. Furthermore, no available data exist for patients with comparable tumors who were randomized to receive or not receive postoperative irradiation. These factors make evaluation of the effect of postoperative radiation therapy difficult. Our data show that when a meningioma is thought at primary operation to be "totally resectable," the control rate by surgery alone approaches 100 per cent and irradiation is unnecessary, irrespective of the histologic type of the meningioma.

If, however, total extirpation of the tumor cannot be achieved because of its location, local invasion, adherence to vital structures, or excessive vascularity, it appears that benefit may be derived from radiation therapy. In our series, the over-all recurrence rate after subtotal removal of the tumor was 22 per cent for patients given postoperative irradiation to a tumor dose of at least 5,000 rads; this is in contrast to an over-all recurrence rate of 74

TABLE VII

BIOPSY OR SUBTOTAL RESECTION, IRRADIATION (PREOPERATIVE IRRADIATION), AND PLANNED REOPERATION (12)

Interval Post Surgery (years)	Total Removal at Reoperation		Subtotal Removal at Reoperation	
	Alive and Well	Died	Alive and Well	Died
≤5	1	0	1	1
>5–10	4	0	1	0
>10–20	2	1	0	1*
Total	7	1	2	2

* Died of intercurrent disease.

TABLE VIII

HISTOLOGY AND THERAPY*

Histologic Appearance	Total Resection	Subtotal Resection No Irradiation	Subtotal Resection with Irradiation	Preoperative Irradiation	Total
Syncytial	25 (0)	18 (14)	15 (4)	9 (1)	67 (19)
Transitional	43 (0)	28 (19)	15 (5)	3 (1)	89 (25)
Fibroblastic	9 (0)	8 (6)	—	—	17 (6)
Angioblastic	6 (0)	2 (2)	1 (0)	—	9 (2)
Meningeal sarcoma	0 (0)	1 (1)	2 (1)	—	3 (2)
Malignant meningioma	1 (0)	1 (1)	1 (0)	—	3 (1)
Total	84 (0)	58 (43)	34 (10)	12 (2)	188 (55)

* Numbers in parentheses represent subsequent recurrences.

per cent for those patients not irradiated. The difference in recurrence rates takes on added significance in that the post-treatment interval tended to be longer for those patients receiving irradiation as compared with those not irradiated; 53 per cent of those irradiated and 38 per cent of those not irradiated were observed longer than 5 years. Furthermore, as far as could be ascertained, these 2 groups of patients and their meningiomas were comparable. Since there were only 22 nonirradiated and 18 irradiated patients followed more than 5 years, 5 year recurrence free survival rates have not been calculated.

The salvage rate was higher (8 of 16) among those patients who at time of recurrence received irradiation (with or without reoperation). In as many as 17 (63 per cent) of the 27 patients reoperated but not irradiated, the meningiomas have already recurred. Radiation therapy is of value, therefore, in patients who have a recurrence following primary resection.

In the patients who have had biopsy and preoperative radiation therapy followed by a 6 month waiting period, the second, and definitive, surgical procedure appears to have been materially aided by the irradiation. Thus, 8 of 12 meningiomas initially deemed to be incompletely resectable because of the degree of vascularity became resectable, and 7 remain free of recurrence up to 13 years postirradiation.

CONCLUSION

On the basis of these data we conclude that: (1) if a meningioma can be totally resected, surgical excision is the treatment of choice; (2) if resection is incomplete, radiation therapy may prevent or markedly delay recurrence; (3) some previously nonirradiated recurrent meningiomas may be controlled by irradiation for extended periods of time; (4) the resectability of certain highly vascular meningiomas may be increased by preoperative irradiation; and (5) the value of radiation therapy appears unrelated to the histologic type.

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