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Vestibular Schwannoma

Fractionated stereotactic radiotherapy for acoustic neuromas: A prospective monocenter study of about 158 cases

Fabien Litre [a,*], Pascal Rousseaux [a], Nicolas Jovenin [b], Arnaud Bazin [a], Philippe Peruzzi [a], Didier Wdowczyk [c], Philippe Colin [c]

[a] Hôpital Maison Blanche; [b] Institut Jean Godinot, Reims Cedex; and [c] Institut du Cancer Reims Courlancy, Reims, France

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ABSTRACT

Purpose: To evaluate long-term outcomes and efficacy of fractionated stereotactic radiotherapy in the treatment of acoustic neuromas.

Material and methods: Between January 1996 and December 2009, 158 acoustic neuromas were treated by FSR in 155 patients. They received a dose of 50.4 Gy, with a safety margin of 1–2 mm with a median tumor volume at 2.45 mL (range: 0.17–12.5 mL) and a median follow-up duration at 60 months (range: 24–192).

Results: FSR was well tolerated in all patients with mild sequelae consisting in radiation-induced trigeminal nerve impairments (3.2%), Grade 2 facial neuropathies (2.5%), new or aggravated tinnitus (2.1%) and VP shunting (2.5%). The treatment failed in four patients (2.5%) who had subsequent surgery respectively at 20, 38, 45 and 84 months post-FSR. The local tumor control rates were respectively 99.3%, 97.5% and 95.2% at 3, 5 and >7-year of follow-up. For initial Gardner–Robertson Grade 1 and 2 ANs, the preservation of useful hearing was possible in 54% of the cases; only Grade 1 ANs had stabilized during the course of the follow-up with 71% >7 years. However, hearing preservation was not correlated to the initial Koos Stage and to the radiation dose delivered to the cochlea. Tinnitus (70%), vertigo (59%), imbalance (46%) and ear mastoid pain (43%) had greatly improved post-FRS in most patients. Tumor control, hearing preservation and FRS toxicity were quite similar in patients with NF2, cystic acoustic neuroma, prior surgical resection and Koos Stage 4 AN. No secondary tumors were observed.

Conclusion: FSR is a safe and effective therapeutic for acoustic neuromas and could be an alternative to microsurgery. Compared to radiosurgery, there are no contraindications for fractioned doses of stereotactic radiotherapy especially for Stage-4 tumors and patients at high risk of hearing loss.

For the past 10 years, patients with acoustic neuromas (AN) have become knowledgeable about their affection and available treatments: microsurgery, radiosurgery and fractionated stereotactic radiotherapy (FSR). Patients want the best treatment possible, i.e. no facial paralysis, retaining useful hearing, spending as little time as possible in the hospital and returning to work quickly.

Due to the obvious toxicity of microsurgery and RS in the initial data as reported in the literature, we started developing FSR in 1990. Then, from 1996 all patients not eligible for microsurgery were treated by FSR according to the same technical modalities and were followed for clinical evaluation, hearing status and MRI by the same neurosurgeon. The main objective of this prospective study was to assess the outcomes of all our former patients treated for AN between January 1st, 1996 and December 31st, 2009 to collect data on tumor control, and radiation-induced neuropathies, hearing preservation, incidence of hydrocephalus (HC) and subsequent venticuloperitoneal (VP) shunting. A secondary objective was to evaluate the evolution of rarely studied symptoms: tinnitus, imbalance, vertigo, ear and mastoid pain (EMP), previous trigeminal and facial impairments. This prospective follow-up is still ongoing.

Patients and methods

Patient characteristics

Because only one patient was lost to follow-up (cirrhosis-related death), 155 evaluable patients were treated consecutively in our center by FSR between January 1st, 1996 and December 31st 2009. Three patients with bilateral AN (NF2) were treated, amounting to a total of 158 AN. After multidisciplinary discussion FSR was only indicated in patients with progressive otological symptoms, regardless of the tumor's size. Patients with axial

* Corresponding author. Address: CHU Reims, Service de Neurochirurgie, Hôpital Maison Blanche, 45 r Cognacq Jay, 51092 Reims Cedex, France.
E-mail address: flitre@chu-reims.fr (F. Litre).

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Table 1
Characteristics of 158 acoustic neuromas in 155 patients.

AN characteristics		Number of patients (total 155)*	Number of AN (total 158)	Percentage (%)	Tumor volume
Koos classification	Stage1	19	19	12	Median 2.45 mL
	Stage 2	61	62	39.3	(*R*: 0.17–12.5)
	Stage 3	51	53	33.5	
	Stage 4	24	24	15.0	
Bilateral acoustic neuromas (neurofibromatosis type 2)		5	8	5	
Previous surgery		13	13	8.2	
Hydrocephalus prior to FSR		9	9	5.6	
Cystic AN		6	6	3.8	
Useful hearing (Grades 1 and 2)		59	61	38.5	
Gardner–Robertson hearing scale	Grade 1	26	27	17	
	Grade 2	32	34	21.5	
	Grade 3	46	46	29.2	
	Grade 4	19	19	19	
	Grade 5	32	32	20.3	
Pre-FSR facial nerve status House–Brackmann scale	Grade1	145	148	93.7	
	Grade 2	9	9	5.7	
	Grade 3	1	1	0.6	
Pre-FSR trigeminal (V) nerve status	No affection	135	136	86	
	Hypoesthesia	10	11	7	
	Anesthesia	0	0	0	
	Paresthesia	6	7	2.5	
	Neuralgia	4	4	2.5	
Tinnitus personal classification	Grade 0	55	57	36	
	Grade 1	26	27	17	
	Grade 2	57	57	36	
	Grade 3	17	17	11	
Vertigo	No	114	114	72	
	Yes	41	44	28	
Ear and mastoid pain	No	122	123	78	
	Yes	33	35	22	
Imbalance	No	90	90	57	
	Yes	65	68	43	

Koos classification: Stage 1: tumor confined to the IAC; Stage 2: tumor <2 cm in diameter; Stage 3: tumor >2 cm, not compressing the brain stem; Stage 4: tumor compressing the brain stem regardless of its size.
Gardner–Robertson hearing scale: Grade 1: good, Grade 2: serviceable, Grade 3: non-serviceable, Grade 4: poor, Grade 5: deaf.
House–Brackmann facial weakness scale grade description: 1: Normal symmetrical function in all areas; 2: slight weakness; 3: obvious weakness, but not disfiguring; 4: obvious disfiguring weakness; 5: motion barely perceptible; 6: no movement, loss of tone.
Tinnitus personal classification: Grade 0 = no tinnitus; Grade 1 = non irritating; Grade 2 = irritating; Grade 3 = very irritating.
Legends: AN = acoustic neuroma; R = range.
* Total of 155 patients (72 men and 83 women) Mean age 53.5 ± 13.6 (R: 18–84).

symptoms were considered not eligible for FSR and had surgery. Patients' characteristics are summed up in Table 1, using Koos classification for AN, 3-D volumetric measurements for pre-treatment volume assessment, House–Brackmann scale was used for facial nerve status and Gardner–Robertson Scale for hearing status. Trigeminal nerve damage was evaluated based on the presence or absence of: paresthesia, hypoesthesia, anesthesia and facial neuralgia. Tinnitus was graded according to our own scale: Grade 0 for no tinnitus, 1 non-irritating, 2 irritating and 3 very irritating tinnitus.

Follow-up: All along patients were clinically evaluated yearly and at the end of the study by the same neurosurgeon and ENT specialist who evaluated all patients' hearing status using tone and speech audiograms. After re-reading the MRI, AN growth control is validated by: stabilized or decreased tumor volume with no clinical aggravation and finally the tumor not requiring microsurgery.

Treatment characteristics

Initially, FRS was delivered by adapted LINAC fitted with BRAINLAB® M3 Brain Lab micro-multileaves and EXAC TRAC IGRT system then replaced by a NOVALIS TX dedicated LINAC. The planning target volume (PTV) was initially determined as GTV +2 mm margin and then +1 mm margin on NOVALIS TX. A peripheral dose of 50 Gy, and a central dose of 55 Gy were delivered in five fractions of 1.8 Gy weekly over 6 weeks through five dynamic arc therapies through a single isocentric method. Median PTV was 2.7 mL (1.5–15.5) and the median Conformity Index was 1.63 (1.24–3.01). Mean maximum doses to cochlea were 40.25 ± 7.5 Gy (30.6–51.3).

Statistical analysis

Using SAS software version 9.0, we reported mean (m) values with standard deviations (±). AN control rate was evaluated with the Kaplan–Meier curve, means comparison was computed with Student's t-test and percentage comparison with Pearson's Chi^2 test with statistical significance set at $p < 0.05$.

Results

With a median 60-month FU (24–192) on 155 patients (158 AN), four AN- unrelated deaths in non-progressive acoustic neuromas were recorded respectively at 26, 26, 32 and 48 months post-FSR. No interruption in the FSR protocol or toxicity-related sick leave was observed.