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Response of ammonium tartrate ESR dosimeters to proton clinical beams

A. Bartolotta[1], M. Brai[2], V. De Caro[3], M.C. D'Oca[1], L.I. Giannola[3], A. Kacperek[4], G. Teri[2]

1. *Dipartimento Farmacochimico Tossicologico e Biologico, Università di Palermo, Via Archirafi 32, 90123 Palermo (Italy)*
2. *Dipartimento di Fisica e Tecnologie Relative, Università di Palermo, 90123 Palermo (Italy)*
3. *Dipartimento di Chimica e Tecnologie Farmaceutiche, Università di Palermo, 90123 Palermo (Italy)*
4. *Clatterbridge Centre for Oncology, Bebington (UK)*

Abstract

In this work we discuss the results of an experimental study aimed to evaluate the dosimetric properties of 1 mm thick ammonium-tartrate pellets, manufactured at Palermo University, and irradiated with the 60 MeV clinical proton beam at the Clatterbridge Centre for Oncology. The pellets were irradiated at different depths inside a water equivalent phantom, to study the dependence of their response on proton energy. The relative effectiveness was significantly different from unity only at the lowest tested proton energy (13 MeV). This result, together with dose dependence and time stability of the response, indicates that ammonium tartrate dosimeters could find application in proton therapy.

KEYWORDS: Proton therapy, proton dosimetry, ESR dosimetry, ammonium tartrate.

Choroidal melanoma treatment with proton beam: first nine years of experience of the Genoa Ocular Oncology Group

C. Mosci[1*], A. Polizzi[2], S. Squarcia [3], B. Mascialino[3], P. Chauvel[4], M. Zingirian[2]

1. *Divisione Oculistica Ospedale Celesia ASL 3, Genova (Italy)*
2. *Dipartimento Scienze Neurologiche e della Visione, Università degli Studi di Genova, Sezione Oftalmologia B, Genova (Italy)*
3. *Dipartimento di Fisica, Università degli Studi di Genova e Sezione TERA, Genova (Italy)*
4. *Centre Antoine Lacassagne Cyclotron Biomedical, Nice (France)*

Abstract

This paper presents the statistical results of the first nine years of activity on proton beam therapy for ocular melanoma treated by the Genoa Ocular Oncology Group. The sample is composed by 127 patients, coming from all Italy, treated at Centre Antoine Lacassagne of Nice. In the considered follow-up we have an average time of 21 ± 5 months with some patient followed till 72 months. With this therapy we obtain a local tumour control in 96.8% of cases with an eye retention of 93.8%. Dividing the patients in T1/T2 tumour group and T3 tumour group we observe that a visual acuity better than 2/10 is retained in 30% in the first one and in 21% for the second one. Seven patients died due to metastasis. The global survival rate after 42 months is 90%.

KEYWORDS: Proton beam, ocular melanoma, medical statistics.

Macular Degeneration Treatment at Clatterbridge Centre for Oncology: Treatment and Preliminary Results

A. Kacperek[1], M. Briggs[2], M.A. Sheen[1], B.E. Damato[2], R.D. Errington[1], S. Harding[2]

1. *Douglas Cyclotron Unit, Clatterbridge Centre for Oncology, CH63 4JY (UK)*
2. St Paul's Eye Unit, Royal Liverpool University Hospital, Liverpool, L7 8XP (UK)

Abstract

Pilot study and randomised control trials, of the efficacy of low dose of protons, have taken place in treating age-related macular degeneration (ARMD). Patients were entered into the trial, through a defined protocol, based on age, CNV presentation and minimum visual acuity, and were randomised between treatment and control. Initially, 38 and 20 were in the treated and control arm respectively. Patients were treated with 18 proton Gy in 4 fractions, based on previous experience of treating choroidal haemangiomas, using light field positioning and circular collimators. 12 month follow-up results, in terms of Visual Acuity, which represent the majority of patients, are presented and show net benefit, for the 28 treated in contrast to the 20 control patients. Additions to EYEPLAN V.1.6, modelling on the inner sclera and circular fields, have enabled simple planning ARMD.

KEYWORDS: Macula, proton theraphy, EYEPLAN, low-dose.

Preliminary results in solid state dosimetry of proton beams for ocular pathology treatment

C. De Angelis[1], S. Onori[1], M. Pacilio[1], E. Petetti[1], L. Azario[2], A. Fidanzio[2], R. Miceli[2], A. Piermattei[2], G. Cuttone[3], L. Raffaele[3], A. Kacperek[4]

1. *Istituto Superiore di Sanità, Roma (Italy)*
2. *Università Cattolica del Sacro Cuore, Roma (Italy)*
3. *Laboratorio Nazionale del Sud, INFN, Catania (Italy)*
4. *Clatterbridge Centre for Oncology, Clatterbridge (UK)*

Abstract

Thin solid state detectors are attractive for relative and absolute dosimetry of therapeuticy proton beams complementing ionisation chamber measurements. In the framework of a wide collaboration, we have been studying dosimetric properties of p-type stereotactic silicon diode detectors (Scanditronix, 60 mm, 0.06 mm thick) and natural diamond detectors (PTW, 260 mm, 0.26 mm thick). Here we report preliminary results on depth dose measurements performed with both dosimetry systems in a low energy beam (26.7 MeV nominal energy available at LNS) and in a therapyeutic proton beam (62 MeV available at CCO). Results seem to be in favour of silicon diode even if care must be taken for its proper use.

KEYWORDS: Proton dosimetry, solid state dosimetry, silicon diode, diamond detection.

The uveal melanoma: historical and epidemiologic aspects, risk factors, natural history and prognosis

F. Carta, A. Pinna, S. Demontis, S. Dore, E. Carta

Institute of Ophthalmology, University of Sassari, Sassari (Italy)

Abstract

Melanoma of the uveal tract is the most common primary intraocular tumour in adults. The tumour, extremely rare in children, primarily affects patients in their early 60s. The tumour is rare in nonwhite patients. Risk factors have not been conclusively identified but may include genetic predisposition, ocular melanocytic conditions, and light-colored irides. Although the natural history of untreated uveal melanoma is inadequately documented, a number of factors have been shown to correlate with survival after enucleation.

KEYWORDS: Uveal melanoma, risk factors, natural history, prognosis.

Proton beam eye treatments in Berlin: experiences of the first two years

J. Heese[1], H. Kluge[1], H. Fuchs[1], H. Homeyer[1], H. Morgenstern[1], C. Rethfeldt[1], I. Reng[1], M. Nausner[2], N. Bechrakis[3], K.M. Kreusel[3], N. Bornfeld[4], W. Hinkelbein[2], M.H. Foerster[3]

1. *Hahn-Meitner Institut, Abt. Ionenstrahltechniken, Glienicker Str. 100, D-14109 Berlin (Germany)*
2. *Strahlenklinik, Universitätsklinikum Benjamin Franklin, Hindenburgdamm 30, D-12200 Berlin (Germany)*
3. *Augenklinik, Universitätsklinikum Benjamin Franklin, Hindenburgdamm 30, D-12200 Berlin (Germany)*
4. *Universitäts-Augenklinik, Hufelandstr. 55, D-45127 Essen (Germany)*

Abstract

From June 1998 to September 2000, altogether 147 eye tumor patients have been irradiated at the HMI eye treatment facility. 73% of the proton beam indications are medium-sized, posterior uveal melanomas close to the optic disc and/or macula (distances to tumor base < 3 mm). Other indications are hemangiomas (15 %), iris melanomas (9%) and conjunctival melanomas (3%). The average patient age is 54 years. In the follow-up of the first patients, tumor regression is clearly visible. However, the average follow-up time is still too short for conclusive results concerning tumor control and side effects.

Patient positioning is done with the usual setup. Special features of the Berlin facility are the treatment chair and the use of X-ray image intensifiers instead of polaroid film. Treatment planning is done using EYEPLAN together with CT scans of the tumor eye to verify marker clips and the shape of the eye globe.

We report on experiences concerning the treatment planning and accuracy and reproducibility of the patient positioning system.

KEYWORDS: Proton therapy, ocular melanoma, patient positioning, treatment planning.

OCTOPUS: a planning tool for proton therapy of eye tumours

K. Pfeiffer[1], B. Dobler[1], C. Rethfeldt[2], W. Schlegel[1], R. Bendl[1]

1. *Deutsches Krebsforschungszentrum, Abt. Medizinische Physik, INF 280, D-69120 Heidelberg (Germany)*
2. *Hahn Meitner Institut, Gleinicker Str. 100, D-14109 Berlin (Germany)*

Abstract

A new 3D treatment planning program OCTOPUS for proton therapy of ocular tumours was developed within a national research project at German Cancer Research Centre, Heidelberg and Hahn-Meitner-Institute, Berlin. By adequate consideration of modern three-dimensional image modalities (e.g., CT and/or MRI sequences) together with fundus photographs and the already used diagnostic information a precise elliptical model of the patient's eye can be established. This way the program should help to minimise planning uncertainties. In addition the precision should be increased by a pencil beam algorithm, which considers the inhomogeneous density and describes scattering accurately. Particular attention was paid to a modern graphical user-interface, which should help to speed up the planning and optimisation process by integrating an additional real-time dose calculation. This new algorithm allows the therapist to move the desired dose distribution under visual control in 3D to the appropriate space. This paper gives a short overview over the features realised up to now. At the moment the system is evaluated under clinical conditions.

KEYWORDS: Proton Therapy, model-based segmentation, real-time dose calculation.

Proton Beam Dosimetry at the CCO

A. Kacperek

Douglas Cyclotron Unit, Clatterbridge Centre for Oncology, Wirral CH63 4JY (UK)

Abstract

Absolute or reference proton dosimetry is practised by comparison with a national secondary standard IC, in a ^{60}Co beam. This system is vulnerable to the low dose-rate of the cobalt beam, due to noise and positioning errors. The simplicity of Faraday Cup proton dosimetry has been shown deceptive. Inter-centre dose intercomparisons minimise errors in dosimetry. The short proton ranges, required in some superficial treatments, have required the use of thin, flat ionisation chambers, which are not mentioned in proton protocols.

Conventional radiotherapy dosimetry techniques, both absolute and relative, have disadvantages. A key problem rests on the high ionisation density of low-energy protons at the Bragg peak. The track-like energy deposition of low energy protons causes a 'saturated', non-linear dose-response. The limitations of existing methods, such as V-film, TLD and MRI gels will be discussed. Geometry and size limit ionisation chambers, while diodes exhibit dose-rate effects. The physical beam characteristics, which may be different at each facility, have been shown to impinge on the radiobiological response of a beam, which may have clinical consequences.

KEYWORDS: Proton dosimetry, Faraday cup, collimator effects, Bragg peak.

Potentiality of proton beam in radiotherapy

M. Krengli[1], R. Orecchia[2], N.J. Liebsch[3], J.E. Munzenrider[3]

1. *Divisione di Radioterapia, Università del Piemonte Orientale, Novara (Italy)*
2. *Divisione di Radioterapia, Istituto Europeo di Oncologia, Università di Milano, Milano (Italy)*
3. *Department of Radiation Oncology, Massachusetts General Hospital, Boston, MA (USA)*

Abstract

The clinical use of protontherapy began in 1954 at Uppsala University in Sweden and in 1961 at Harvard Cyclotron Laboratory (HCL) in Boston, USA. The proton beam has physical and radiobiologic characteristics which differ from those of conventional radiotherapy. The main advantage is due to the Bragg peak that can be modulated and spread out in order to obtain the best coverage of the target volume. The RBE for protons does not substantially differ from that of photons and the value of 1.1 is generally accepted in clinical practice. After a few decades experience, the main clinical indications remain proximity of the target area to critical structures, low tumour radiosensitivity necessitating high doses, and a high benefit to cost ratio. For the tumors that meet these criteria, such as uveal melanomas and chondrosarcomas and chordomas of the base of skull and spinal region, protontherapy may be superior to photon beam therapy. For other malignancies, including tumors of the brain, head and neck, prostate, as well as soft tissue sarcomas, where improved local control is likely to result in higher rates of definitive cure, preliminary results are promisisng but large comparative treatment studies are still needed.

KEYWORDS: Proton beam, uveal melanoma, skull base tumors, radiotherapy.

Relative Biological Effectiveness for inactivation in cells irradiated with the 65 MeV proton beam at the Cyclotron Medicyc in Nice

D. Bettega[1], P. Calzolari[1], P. Chauvel[2], A. Courdi[2], J. Herault[2], N. Iborra[2], R. Marchesini[3], P. Massarillo[1], G.L. Poli[1], L. Tallone[1]

1. *Dipartimento di Fisica. Università di Milano. Via Celoria 16, I-20133 Milano (Italy)*
2. *Centro Antoine-Lacassagne, Batiment du Cyclotron, 227 Avenue de la Lanterne, F-06200 Nice (France)*
3. *Istituto Nazionale dei Tumori, Via Veneziani 1, I-20133 Milano (Italy)*

Abstract

We have determined the relative biological effectiveness, RBE, of the 65 MeV therapeutic beam at the Cyclotron Medicyc in Nice for initial and delayed inactivation on human tumour cells. RBE has been determined at five positions along the beam: one at the entrance, two on the Spread-Out Bragg Peak, SOBP, and two on the declining distal edge. SCC25 cell line derived from an human squamous cell carcinoma of the tongue has been used. RBEs are between 1-1.2 within the SOBP and then increase up to 2 in the declining distal edge. The delayed reproductive cell death is significantly high at each positions. The shape of the dose-effect curves are more shouldered than the survival curves of the directly irradiated cells.

KEYWORDS: Proton beams, RBEs, survival, delayed reproductive cell death.

Applications and possible generalisations of a method tested at the OPTIS facility, for analysing physical and radiobiological properties of therapeutic proton beams

M. Biaggi[1,2], F. Ballarini[1,2], W. Burkard[3], E. Egger[3], A. Ferrari[2,4], A. Ottolenghi[1,2], D. Scannicchio[5]

1. *Università degli Studi di Milano, Dipartimento di Fisica, Via Celoria 16, 20133 Milano (Italy)*
2. *INFN, Sezione di Milano Milano (Italy)*
3. *Paul Scherrer Institut, Villigen (Switzerland)*
4. *CERN, Geneva (Switzerland)*
5. *Università di Pavia, Dipartimento di Fisica Nucleare e Teorica, Via U. Bassi 6, 27100 Pavia (Italy)*

Abstract

A method developed to analyse the physical and biophysical properties of therapeutic proton beams and more in general to estimate mixed field effects, previously tested at the OPTIS facility (Paul Scherrer Institut, Switzerland), was applied to a 160 MeV proton beam, modulated to obtain a therapeutic Spread-Out Bragg Peak (SOBP). The spatial distribution of dose in a water phantom was calculated with the condensed-history MC code FLUKA. The yield of DNA Complex Lesions (CL, which were found to play a relevant role in cell inactivation and other radiobiological endpoints), reflecting the radiation clustering properties, had been previously calculated using an event-by-event code and integrated in FLUKA. The code this way obtained provides the spatial distribution of CL per cell, which can be regarded as a 'biological dose'. The contribution of the secondary hadrons to the biological dose was found to be much more relevant with respect to the case of the physical dose and therefore cannot be neglected. An RBE of $\approx$ 1.2 was found along the plateau and in most of the SOBP (due to secondary hadrons), with a sharp increase in the distal part (due to the presence of low energy protons). The 'biological peak' resulted to be shifted towards larger depths with respect to the physical peak. The results are in good agreement with experimental data reported in the literature.

KEYWORDS: Monte Carlo simulations, mixed fields, proton therapy, RBE, Spread-Out Bragg Peak.

A pixel ionization chamber as monitor for therapeutical hadron beams

S. Belletti[1], R. Cirio[2], M. Donetti[3], B. Ghedi[1,5], E. Madon[4], F. Marchetto[2], C. Peroni[2], C. Sanz Freire[2], E. Trevisiol[4], A. Urgesi[4]

1. *Servizio di Fisica Sanitaria, Spedali Civili di Brescia, P.le Ospedale 1, I-25123 Brescia (Italy)*
2. *Dipartimento di Fisica Sperimentale and INFN of Torino, V. Giuria 1, I-10125 Torino (Italy)*
3. *TERA Foundation, Via Puccini 11, I-28100 Novara (Italy)*
4. *OIRM S. Anna, Via Baiardi 43, I-10126 Torino (Italy)*
5. *ASP, Viale Settimio Severo 65, I-10133 Torino (Italy)*

Abstract

A fast and precise detector is essential for exploiting the therapeutical capabilities of radiotherapy with hadron beams. We have developed a large area ionization chamber that allows 2D reconstruction in real time. The chamber features a pixel-segmented electrode with up to 1024 pixels of 7.5 mm side. Each pixel is connected to a current-to-frequency converter channel implemented in a 64 channels VLSI chip. The chips are read out with fast IO modules connected to a microprocessor that runs the VxWorks real time operating system. This architecture allows fast readout (50 μs for 1024 channels). The data acquisition has also been realized with a cheaper and slower (1 ms readout time) system that uses a PCI IO card on a PC running LabVIEW. Results of tests on proton and carbon ions beams are reported.

KEYWORDS: Beam monitoring, dosimetry, hadrontherapy, ionization chamber.

Thermoluminescent CVD diamond films for dosimetric applications

S. Mazzocchi[4,6], M. Bruzzi[2,4], M. Bucciolini[1,4], G. Cuttone[3], A. Guasti[4,6], S. Pini[2,4], S. Pirollo[2,4], M.G. Sabini[3,5], S. Sciortino[2,4]

1. *Dipartimento di Fisiopatologia Clinica, Università di Firenze, Viale Morgagni, Florence (Italy)*
2. *Dipartimento di Energetica, Via S. Marta 3, 50139 Firenze (Italy)*
3. *INFN - Laboratori Nazionali del Sud, Via S. Sofia 44, 95100 Catania (Italy)*
4. *INFN - Sez. Firenze, Largo E. Fermi 2, Firenze (Italy)*
5. *Dipartimento di Fisica, Università di Catania, Corso Italia 57, Catania (Italy)*
6. *Servizio Fisica Sanitaria, A.O. Careggi, Firenze (Italy)*

Abstract

The present technology allows to employ synthetic polycrystalline diamond films as dosimeters for radiotherapic applications. Diamond films can now be grown with different kinds and amounts of impurities and potential low cost. Moreover, due to the high sensitivity and stability of the material, diamonds can be tailored in small sizes, making them suitable for the characterisation of small radiation fields.

In this work the dosimetric properties of two generation of thermoluminescent CVD (Chemical Vapour Deposited) diamond films have been studied with radiation beams of different L.E.T. (^{60}Co photons, photons and electrons from Linac, 26 MeV protons from Tandem accelerator) in the dose range 0.1Gy-7 Gy.

KEYWORDS: CVD diamond, Thermoluminescence, Dosimetry.

Microdosimetric Measurements of the Nice Therapeutic Proton Beam

V. Cesari[1], P.N. Iborra[2], L. De Nardo[3], P. Querini[1], V. Conte[1], P. Colautti[1], G. Tornielli[3], P. Chauvel[2]

1. *INFN - Laboratori Nazionali di Legnaro, Via Romea 4, I-35020 Legnaro (Italy)*
2. *Centre Antoine Lacassagne Biomedical Cyclotron, 227 Avenue de la Lanterne, F-06200 Nice (France)*
3. *University of Padova, Physics Departement, Via Marzolo 8, I-35131 Padova (Italy)*

Abstract

Proton beams are used with success in some ocular pathologies. However, in order to spare the healthy tissues as more as possible, more accurate therapeutic plans, which take into account their physical quality change with the depth in tissue, should be envisaged. In this paper we have measured the physical quality, and its variation with the depth, of the proton therapeutic beam of the Centre Antoine-Lacassagne of Nice (France). The physical quality has been measured by using microdosimetric techniques. Measurements have been performed with a mini TEPC, the sensitive volume of which, of less than 1 mm^3, was filled with tissue-equivalent gas mixture to simulate a tissue diameter of 1 μm. Experimental data show a significant increase of the beam quality in the distal edge of the SOBP.

KEYWORDS: Microdosimetry, proton therapy, mini TEPC.

Inhibition of Human Melanoma Cell Growth by Proton Irradiation

A. Ristić-Fira[1], D. Todorović[1], I. Petrović [1], S. Ružđijić[1], L. Raffaele[2], M.G. Sabini[2], G.A.P. Cirrone[2], G. Cuttone[2], G. Farruggia[3], L. Masotti[3], D.T. Kanazir[1]

1. *Institute of Nuclear Sciences Vinča, Belgrade (Yugoslavia)*
2. *INFN - Laboratori Nazionali del Sud, Catania (Italy)*
3. *Department of Biochemistry G. Moruzzi, University of Bologna, Bologna (Italy)*

Abstract

The aim of this work is the *in vitro* study of human melanoma cell growth modulation after irradiation with protons. Confluent cell monolayers were irradiated with single doses ranging from 1 to 20 Gy, using proton beams having energy of 22.6 MeV at the target. 48 hours after irradiation, cell growth, cell cycle analyses and initiation of cell death were followed. The obtained results were compared with the effects of glucocorticoid hormones.

The inhibition of melanoma cell growth was observed, especially after single application of 12 and 16 Gy. Cell cycle analyses of melanomas after proton irradiation, have shown the G2/M arrest of irradiated cells corresponding with the increase of applied dose. The flow cytometric analysis has shown presence of apoptotic nuclei. Glucocorticoid treatment has shown modest melanoma cell growth inhibition, cell cycle arrest in G2/M phase and 'ladder' pattern on agarose gel electrophoresis.

KEYWORDS: HTB63 human melanoma cells, proton irradiation, cell cycle, apoptosis.

Glow curve deconvolution of response of LiF dosimeters to proton clinical beams: energy dependence

M. Brai[1,6], A. Bartolotta[2,6], S. Basile[1], G. Bruno[1], G. Cuttone[3], A. Kacperek[4], G. Teri[1,6]

1. *Dipartimento di Fisica e Tecnologie Relative and Unità INFM, Università di Palermo, Via Parlavecchio 3, 90127 Palermo (Italy)*
2. *Dipartimento Farmacochimico Tossicologico e Biologico, Università di Palermo, Palermo (Italy)*
3. *LNS-INFN, Catania (Italy)*
4. *Clatterbridge Center for Oncology, Bebington (UK)*
6. *Sezione INFN di Catania, Catania (Italy)*

Abstract

Glow curve analysis was carried out to study the response of two types of standard LiF TL (TLD100 and GR200) dosimeters irradiated in proton beams with different energy. The aim of the study was to have a better understanding of the role of material characteristics in determining their glow curve response when irradiated with proton beams. Irradiation were carried out at different depths inside a water equivalent phantom in the Clatterbridge Centre for Oncology (CCO) with 60 MeV protons. The results showed a decrease of the dosimetric sensitivity with the increasing LET of the proton beam. The ratio between the peaks of TL emission in the high temperature region (HTR parameter in TLD100) and in the low temperature region (LTR parameter in GR200) and the dosimetric peak in the energy range from 10 up to 60 MeV was studied in comparison with that of ^{60}Co radiation. The peak structure of the glow curves of TLD100 and GR200 LiF dosimeters were deconvoluted within the frame of kinetic model of general order.

KEYWORDS: TL dosimetry, proton dosimetry, GCD, LiF.

Use of 62 MeV Proton Beam for Medical Applications at INFN-LNS: CATANA Project

G. Cuttone[1], A. Amato[1], A. Bartolotta[5], M. Brai[5], G.A.P. Cirrone[1,6], A. Giammò[1], S. Lo Nigro[4,6], G.A. Nicoletti[2], J. Ott[2], G. Privitera[3], L.Raffaele[1,3], M.L. Rallo[2], C. Rapicavoli[g], A. Reibaldi[2], D. Rifuggiato, N. Romeo[1], A. Rovelli[1], M.G. Sabini[1,4] V. Salamone[3], G. Teri[5] , F. Tudisco[1]

1. *INFN - Laboratori Nazionali del Sud, Catania (Italy)*
2. *Institute of Ophtalmology, University of Catania, Catania (Italy)*
3. *Institute of Radiology, University of Catania, Catania (Italy)*
4. *Physics Department, University of Catania, Catania (Italy)*
5. *Istituto di Biocomunicazioni, University of Palermo, Palermo (Italy)*
6. *Centro Siciliano di Fisica Nucleare e Struttura della Materia, Catania (Italy)*

Abstract

The project CATANA (Centro di AdroTerapia ed Applicazioni Nucleari Avanzate) is a collaboration between the INFN - Laboratori Nazionali del Sud (LNS), Physics Department, Ophthalmology Institute and Radiology Institute of the Catania University and CSFNSM Catania. The main goal of CATANA is the study and the application of proton therapy for the treatment of shallow tumors (4 cm max) like uveal melanomas and subfoveal macular degenerations.

KEYWORDS: Proton, scatterers, proton theraphy, cyclotron.

The OPTIS facility at PSI: Experience and results

E. Egger

Division of Radiation Medicine, Paul Scherrer Institute, CH-5232 Villigen-PSI (Switzerland)

Abstract

The treatment of ocular tumors with Proton beam radiotherapy (PBRT) was developed in Boston in a common effort of the Harvard Cyclotron Laboratory and the Eye and Ear Infirmary of the Massachusetts General Hospital. This treatment technique has been introduced in Western Europe and further developed by the Paul Scherrer Institute (PSI) in 1984. The main improvement of the PSI facility named OPTIS (Ophthalmologic Proton Therapy Installation Switzerland) was the patient positioning chair, which allows for a fast and reliable positioning of the patient for each fraction. The OPTIS facility at PSI was the model for most of the facilities built after 1984.

By the end of September 2000, more than 3200 patients have been treated with success at this facility. The excellent results published by the Boston and the PSI group have convinced many other centers to introduce PBRT for the treatment of ocular tumors. While only the PSI was treating ocular tumors with protons in Western Europe in 1985, already 6 centers are using this technique in the year 2000 and new centers are planned or in construction.

The aim of this paper is to review the experience gained with the OPTIS facility during 16 years of operation, and to present the main results in terms of local tumor control, complications and vision retention of the irradiated eye. While the rate of local tumor control has reached a level of 99%, the number of patients keeping a useful vision may still be improved. However, it is our conviction that these improvements require a complete modification of the time/dose/fractionation schedule, i.e., the treatment with 8 or even more fractions instead of the 4 fractions applied today. Such fractionation schedules may not be compatible with the beam time allocated to the treatment of patients in a physics research laboratory. Also in Europe, the need for a facility dedicated to patient treatment becomes evident.

KEYWORDS: Uveal melanoma, proton beam radiotherapy, treatment planning, local tumor control.

Radiation therapy of ocular melanoma: pre-clinical experience

R. Santoni, A. Galardi, L. Livi, F. Paiar, G. Biti

Radiation Therapy Unit, Department of Clinical Phisiopathology, University of Florence, Firenze (Italy)

Abstract

Several methods have been developed to treat ocular melanomas and trials are ongoing to obtain reliable data to ascertain the superiority of one treatment over the other in terms of local control, overall survival and frequency of side effects. In spite of the fact that enucleation is accepted to treat the larger tumours the use of radioactive plaques or proton beam irradiation are used in specialised centres and a large experience has been gained with their use. Proton beams are employed in different centres scattered all over the world and have demonstrated their superiority with respect to conventional photon or plaque irradiation. Protons have, in fact, a minimal scattering, a well defined range in tissues and may be collimated in small fields delivering most of their energy at the end of the pre-defined track.

Pre-clinical experience is reviewed with particular attention to the determination of the RBE (Relative Biological Effectiveness) of the protons in comparison to 2 MV photons and to the clinical and histological modifications produced by a collimated modulated and unmodulated beam of protons. Collimated proton beams produce circumscribed areas of chorioretinal scarring without any other long-term serious complications that are usually associated with other radiation therapy modalities. In particular the well demarcated area of chorioretinal scarring present a border (0.5-1.0 mm) with transient modifications immediately surrounded by normal retina. No optic nerve damage is noticed and no serious complication is detected in the anterior segment of the eye.

KEYWORDS: Ocular tumours, melanoma of eye, proton beams, RBE, relative biological effectiveness.

Proton beam dosimetry for the CATANA Project

L. Raffaele[1,2], G.A.P. Cirrone[3,2], G. Cuttone[2], S. Lo Nigro[3,4], M.G. Sabini[3,2], V. Salamone[1,2], E. Egger[5], A. Kacperek[6], N. Romeo[2]

1. *Istituto di Radiologia, Università degli Studi di Catania, Via S. Sofia, Catania (Italy)*
2. *INFN - Laboratori Nazionali del Sud, Via S. Sofia 44, Catania (Italy)*
3. *Dipartimento di Fisica, Università degli Studi di Catania, Corso Italia 57, Catania (Italy)*
4. *Centro Siciliano di Fisica Nucleare e Struttura della Materia, Corso Italia 57, Catania (Italy)*
5. *Paul Scherrer Institute, Villigen (Switzerland)*
6. *Clatterbridge Centre for Oncology, Clatterbridge (UK)*

Abstract

In this work the status of the CATANA Project is reported from a dosimetric point of view. Here the principal choices of CATANA Group, in the development of absolute and relative dosimetric thecniques will be presented

KEYWORDS: Protons, dosimetry, TLD, films.

The TOP Project of the Italian Institute of Health

S. Frullani, M. Grandolfo

Physics Laboratory, Istituto Superiore di Sanità, Roma (Italy)

Abstract

The Italian National Health Service, within the budget assigned to develop innovative research projects, has funded, starting from 1995, ISS (Istituto Superiore di Sanità-Italian National Health Institute) to promote the TOP (Terapia Oncologica con Protoni-Oncological Therapy with Protons) Project whose aim is to design and build a prototype compact proton accelerator with annexed treatment halls. In the framework of a cooperative agreement, the clinical characteristics of the therapeutic beams in the different halls (one at low energy for ocular diseases treatment and two more at higher energy) have been defined by the Rome Oncological Institute Regina Elena (IRE) which will host and operate the medical facility. The design of the accelerator has been carried out in the framework of an agreement with ENEA (Ente Nazionale per l'Energia e l'Ambiente-National Agency for Energy and Environment) that is interested in the development of an accelerator whose technology can be transferred to the Italian industry. The TOP Project also covers research in the field of radiobiology, dosimetry and networking that are connected with different aspects of Proton Therapy. The project has benefited from the Italian Hadrotherapy (TERA) Collaboration and the INFN (National Nuclear Physics Institute) funded ATER Collaboration. A status report of the development of the TOP Project is presented with the main emphasis on the accelerator design and construction.

KEYWORDS: Proton Therapy, PET radioisotopes, Linac.

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