

PROTON THERAPY LITERATURE

In the treatment of cancer, high doses of radiation are used to destroy cancer cells by damaging their DNA. When the DNA of a cancer cell is destroyed beyond repair, the cell dies and is then eliminated by the body through natural processes.

Proton therapy is an advanced form of radiation treatment that has been used to treat more than 160,000 people worldwide. By 2030, it is estimated that between 300,000 and 600,000 patients will have received proton therapy treatment.

The following are research studies published between 2016 and 2019 that underscore the benefits of proton therapy for certain cancer patients. The majority of the studies employ pencil beam scanning, the most precise form of proton therapy.

PROTON THERAPY (GENERAL)

Garces Y, Remmes N, et. al. [Retrospective Review of Patients With Cardiac Implantable Electronic Devices Treated With Spot Scanning Proton Therapy](#). *Int J Radiat Oncol Biol Phys*. Volume 111, Issue 3, Supplement, 1 November 2021, Page e499. doi: <https://doi.org/10.1016/j.ijrobp.2021.07.1375>

Loizeau N., Fabiano S., et.al. [Optimal allocation of proton therapy slots in combined proton-photon radiotherapy](#). *Int J Radiat Oncol Biol Phys*. 2021 April 20; doi: 10.1016/j.ijrobp.2021.03.054.

Lamirault C, Doyere V, et.al. [Short and long-term evaluation of the impact of proton minibeam radiation therapy on motor, emotional and cognitive functions](#). *Sci Rep*. 2020; 10: 13511.

Li G, Qui B, et. al. [Cost-effectiveness analysis of proton beam therapy for treatment decision making in paranasal sinus and nasal cavity cancers in China](#). *BMC Cancer*. 2020 June 26.

B. Baumann, N. Mitra, J. Harton, et. al. [Comparative Effectiveness of Proton vs Photon Therapy as Part of Concurrent Chemoradiotherapy for Locally Advanced Cancer](#). *JAMA Oncol*. 2019 Dec 26.

Yuan TZ, Zhan ZJ, Qian CN. [New frontiers in proton therapy: applications in cancers](#). *Cancer Comun (Lond)*. 2019 Oct 22; 39(1):61.

Gao M, Mohiuddin MM, Hartsell WF, et. al. [Spatially fractionated \(GRID\) radiation therapy using proton pencil beam scanning \(PBS\): Feasibility study and clinical implementation](#). *Med Phys*. 2018 Apr;45(4):1645-1653.

Carter R, Nickson C, et. al. Complex DNA Damage Induced by High Linear Energy Transfer Alpha-Particles and Protons Triggers a Specific Cellular DNA Damage Response. Int J Radiat Oncol Biol Phys. 2018 Mar 1; 100(3):776-784.

Bright SJ, Flint DB, Chakraborty, et. al. Non-homologous end joining is more important than proton linear energy transfer in dictating cell death. Int J Radiat Oncol Biol Phys. 2019 Aug 16.

Giantsoudi D, Adams J, MacDonald S, Paganetti H. Can differences in linear energy transfer and thus relative biological effectiveness compromise the dosimetric advantage of intensity-modulated proton therapy as compared to passively scattered proton therapy? Acta Oncol. 2018 May 4:1-6.

BREAST

R Lin, J. Shan., et.al. [Dosimetric comparison of intensity-modulated proton radiotherapy versus intensity-modulated photon-based radiotherapy for breast cancer](https://doi.org/10.1051/vcm/2021002). Vis Cancer Med, Volume 2, 5 2021. Doi: <https://doi.org/10.1051/vcm/2021002>

Cartechini G, Fracchiolla F, et, al. [Proton pencil beam scanning reduces secondary cancer risk in breast cancer patients with internal mammary chain involvement compared to photon radiotherapy](https://doi.org/10.1016/j.radonc.2020.10.022). Radiation Oncology 15: 228. 2020 Oct 02.

Justin E Bekelman, Hien Lu, Stephanie Pugh. et. al. Pragmatic randomised clinical trial of proton versus photon therapy for patients with non-metastatic breast cancer: the Radiotherapy Comparative Effectiveness (RadComp) Consortium trial protocol. BMJ Open. 2019; 9(10): e025556.

D. Pasalic, E.A. Strom, P.K. Allen, et, al. Prospectively Assessed Outcomes for Proton Accelerated Partial Breast Irradiation. Int J Radiat Oncol Biol Phys. 2019 Sep 1; 105 (1): S193

J.A. Bradley¹, X. Liang, M.S. Rutenberg, et, al. Three Year Outcomes of Proton Therapy for Regional Nodal Irradiation in Breast Cancer. Int J Radiat Oncol Biol Phys. 2019 Sep 1; 105 (1): E1

J.R. Niska, C.S. Thorpe, J. Anderson, et, al. Post-Mastectomy Radiotherapy using Proton Beam Therapy: Prospective Multi-Institutional PCG Registry Analysis. Int J Radiat Oncol Biol Phys. 2019 Sep 1; 105 (1): E6

I.J. Choi, K. Prabhu Jr., W.F. Hartsell, et, al. Clinical Outcomes after Proton Partial-Breast Radiotherapy for Early-Stage, Hormone Receptor-Positive Breast Cancer: 3-Year Outcomes of a Phase II Trial. Int J Radiat Oncol Biol Phys. 2019 Sep 1; 105 (1): E19

C.S. Thorpe, J.R. Niska, J. Anderson, et. al. Proton Beam Therapy after Breast-Conserving Surgery for Breast Cancer: Multi-institutional Prospective PCG Registry Analysis. Int J Radiat Oncol Biol Phys. 2019 Sep 1; 105 (1): E35

Speleers B, Belosi FM, et. al. Comparison of supine or prone crawl photon or proton breast and regional lymph node radiation therapy including the internal mammary chain. Sci Rep. 2019 Mar 18;9(1):4755.

Leo L, Cuaron et al. Early outcomes of breast cancer patients treated with post-mastectomy uniform scanning proton therapy. Radiotherapy and Oncology. 2018.

Smith N, Jethwa KR, et. al. Early Toxicity and Patient Reported Outcomes of Post-Mastectomy Pencil-Beam Scanning Proton Therapy in Women with Immediate Tissue Expander Breast Reconstruction. Int J Radiat Oncol Biol Phys. 2018 Nov. 102(suppl 3): e573–e574.

Stick L, Yu J, et. al. Joint Estimation of Cardiac Toxicity and Recurrence Risks After Comprehensive Nodal Photon Versus Proton Therapy for Breast Cancer. Int J Radiat Oncol Biol Phys. 2017 Mar 15;97(4):754-761.

Bradley JA, Dagan R, et. al. Initial Report of a Prospective Dosimetric and Clinical Feasibility Trial Demonstrates the Potential of Protons to Increase the Therapeutic Ratio in Breast Cancer Compared With Photons. Int J Radiat Oncol Biol Phys. 2016 May 1;95(1):411-21.

Jimenez RB, Hickey S, DePauw N, et. al. Phase II Study of Proton Beam Radiation Therapy for Patients With Breast Cancer Requiring Regional Nodal Irradiation. J Clin Oncol. 2019 Aug 26.

GYNECOLOGIC

Boer P, van de Schoot A, Westerveld H, et. al. Target tailoring and proton beam therapy to reduce small bowel dose in cervical cancer radiotherapy: A comparison of benefits. Strahlenther Onkol. 2018 Mar;194(3):255-263.

Lin LL, Kirk M, Scholey J, et. al. Initial Report of Pencil Beam Scanning Proton Therapy for Posthysterectomy Patients With Gynecologic Cancer. Int J Radiat Oncol Biol Phys. 2016 May 1;95(1):181-9.

HEAD AND NECK

Sheikh, Saad MD; Kharouta, Michael Z. MD, et al. [Proton Beam Therapy for Locally Advanced Head and Neck Tumors](#). *American Journal of Clinical Oncology*: December 08, 2021 - Volume - Issue - doi: 10.1097/COC.0000000000000883

Scher N, Bentahila G, et. al. [Proton Therapy for Adult Craniopharyngioma](#). *Int J Radiat Oncol Biol Phys*. Volume 111, Issue 3, Supplement, 1 November 2021, Page e561. doi: [https://www.redjournal.org/article/S0360-3016\(21\)02388-9/pdf](https://www.redjournal.org/article/S0360-3016(21)02388-9/pdf)

Hung HM, Chan OCM, et. al. [Dosimetric comparison of intensity modulated radiotherapy and intensity modulated proton therapy in the treatment of recurrent nasopharyngeal carcinoma](#). *Medical Dosimetry*, August 29,2021. doi: <https://doi.org/10.1016/j.meddos.2021.07.002>.

Y.H. Lin, J.Y. Cheng., et.al. [Significant Reduction in Vertebral Artery Dose by Intensity Modulated Proton Therapy: A Pilot Study for Nasopharyngeal Carcinoma](#). *J. Pers. Med.* 2021, 11(8), 822; <https://doi.org/10.3390/jpm11080822>

Chou YC., Fan KH., et. al. [Intensity Modulated Proton Beam Therapy versus Volumetric Modulated Arc Therapy for Patients with Nasopharyngeal Cancer: A Propensity Score-Matched Study](#). *Cancers (Basel)*. 2021 Jul 16;13(14):3555. doi: 10.3390/cancers13143555.

Thaker NG, Boyce-Fappiano D, et al. [Activity-Based Costing of Intensity-Modulated Proton versus Photon Therapy for Oropharyngeal Cancer](#). *Int J Part Ther*. 2021 Jun 25;8(1):374-382. doi: 10.14338/IJPT-20-00042.1.

Li XZ, Kitpanit S, et al. [Toxicity Profiles and Survival Outcomes Among Patients With Nonmetastatic Nasopharyngeal Carcinoma Treated With Intensity-Modulated Proton Therapy vs Intensity-Modulated Radiation Therapy](#). *JAMA Netw Open*. June 18, 2021;4(6):e2113205. doi:10.1001.

Williams M.V., Parvathaneni U., et.al. [Intensity-Modulated Proton Therapy for Nasopharynx Cancer: 2-year Outcomes from a Single Institution](#). *Int J Part Ther* (2021); doi: 10.14338/IJPT-20-00057.1.

Brodin NP, Kabarriti, et.al. [Individualized quality of life benefit and cost-effectiveness estimates of proton therapy for patients with oropharyngeal cancer](#). *Radiat Oncol*. 2021 Jan 21. Doi: 10.1186/s13014-021-01745-1.

Nguyen M, Cantrell N, Athmad S, Henson C. [Intensity-modulated proton therapy \(IMPT\) versus intensity-modulated radiation therapy \(IMRT\) for the treatment of head and neck cancer: A dosimetric comparison](#). *Medical Dosimetry*. 2021 Feb 26.

Pelak M, Walser M, et. al. [Clinical outcomes of head and neck adenoid cystic carcinoma patients treated with pencil beam-scanning proton therapy](#). *Oral Oncol*. Volume 107, 2020 Aug; 104752.

Fan M, Kang JJ, Lee A, et.al. [Outcomes and toxicities of definitive radiotherapy and reirradiation using 3-dimensional conformal or intensity-modulated \(pencil beam\) proton therapy for patients with nasal cavity and paranasal sinus malignancies](#). *ACS J*. 2020 Feb 25.

G.L. Smith, M.S. Ning, et, al. Impact of Intensity-Modulated Proton Therapy vs. Intensity-Modulated Photon Therapy on Preserving Work and Productivity in Oropharyngeal Cancer Patients: Outcomes of a Multi-Institution Randomized Trial. Int J Radiat Oncol Biol Phys. 2019 Sep 1; 105 (1): E427-E428

H. Bahig, A.S. Garden, G.B. Gunn, et, al. Head and Neck Adenoid Cystic Carcinoma: Focus on Outcomes of Intensity Modulated Proton Therapy. Int J Radiat Oncol Biol Phys. 2019 Sep 1; 105 (1): E432

H. Minatogawa, K. Yasuda, T. Matsuura, et, al. The Potential Benefit of Adaptive Intensity Modulated Proton Therapy in Nasopharyngeal Carcinoma: Planning Comparison Study. Int J Radiat Oncol Biol Phys. 2019 Sep 1; 105 (1): E394

V.M. Williams, B. Sasidharan, S. Aljabab, et, al. Proton Radiotherapy for Locally Advanced Nasopharyngeal Carcinoma: Early Clinical Outcomes From a Single Institution. Int J Radiat Oncol Biol Phys. 2019 Sep 1; 105 (1): E397

H. Bahig, G.B. Gunn, A.S. Garden, et, al. Toxicity and Pharyngeal Dysphagia Outcomes from Intensity Modulated Proton Therapy for Oropharyngeal Squamous Cell Cancer. Int J Radiat Oncol Biol Phys. 2019 Sep 1; 105 (1): E410

G.B. Gunn, A.S. Garden, R. Ye, et, al. Clinical Outcomes after Proton Therapy for Head and Neck Cancer: A 12 Year Single Institution Experience. Int J Radiat Oncol Biol Phys. 2019 Sep 1; 105 (1): E373

M. Shuja, D.M. Routman, R.L. Foote, et, al. Clinical Outcomes after Re-irradiation in Recurrent Head and Neck Cancers treated with Intensity Modulated Proton and Photon Therapies. Int J Radiat Oncol Biol Phys. 2019 Sep 1; 105 (1): E382- E383

Pearlstein KA, Wang K, Amdur RJ. Quality of Life for Patients With Favorable-Risk HPV-Associated Oropharyngeal Cancer After De-intensified Chemoradiotherapy. Int J Radiat Oncol Biol Phys. 2019 Mar 1;103(3):646-653.

Moreno A, Frank S, et. al. Intensity modulated proton therapy (IMPT) – The future of IMRT for head and neck cancer. Oral Oncology. 2018 Jan 88:66-74

Sharma S, Zhou O, Thompson R, et. al. Quality of Life of Postoperative Photon versus Proton Radiation Therapy for Oropharynx Cancer. International Journal of Particle Therapy. 2018. In-Press.

Gu W, O'Connor D, Nguyen D, et. al. Integrated beam orientation and scanning-spot optimization in intensity-modulated proton therapy for brain and unilateral head and neck tumors. Med Phys. 2018 Apr;45(4):1338-1350.

De Felice F, Polimeni A, et. al. Radiotherapy Controversies and Prospective in Head and Neck Cancer: A Literature-Based Critical Review. Neoplasia. 2018; 20(3): 227-232.

Langendijk JA, Steenbakkers RJ. Optimizing Radiotherapy in HPV-Associated Oropharyngeal Cancer Patients. *Recent Results Cancer Res*. 2017;206:161-171. Review.

Apinorasethkul O, Kirk M, et al. Pencil beam scanning proton therapy vs rotational arc radiation therapy: A treatment planning comparison for postoperative oropharyngeal cancer *Medical Dosimetry*. 2017; 42 (1): 7-11.

Zhang W, Zhang X, Yang P, et al. Intensity-modulated proton therapy and osteoradionecrosis in oropharyngeal cancer. *Radiother Oncol*. 2017 Jun;123(3):401-405.

van Dijk LV, Steenbakkers RJ, ten Haken B, et al. Robust Intensity Modulated Proton Therapy (IMPT) Increases Estimated Clinical Benefit in Head and Neck Cancer Patients. *PLoS One*. 2016 Mar 31;11(3):e0152477.

Sio TT, Lin HK, Shi Q, et al. Intensity Modulated Proton Therapy Versus Intensity Modulated Photon Radiation Therapy for Oropharyngeal Cancer: First Comparative Results of Patient-Reported Outcomes. *Int J Radiat Oncol Biol Phys*. 2016 Jul 15;95(4):1107-14.

Blanchard P, Garden AS, Gunn GB, et al. Intensity-modulated proton beam therapy (IMPT) versus intensity-modulated photon therapy (IMRT) for patients with oropharynx cancer - A case matched analysis. *Radiother Oncol*. 2016 Jul;120(1):48-55.

McKeever MR, Sio TT, Gunn GB, et al. Reduced acute toxicity and improved efficacy from intensity-modulated proton therapy (IMPT) for the management of head and neck cancer. *Chin Clin Oncol*. 2016 Aug;5(4):54.

Holliday EB, Kocak-Uzel E, Feng L, et al. Dosimetric advantages of intensity-modulated proton therapy for oropharyngeal cancer compared with intensity-modulated radiation: A case-matched control analysis. *Med Dosim*. 2016 Autumn;41(3):189-94.

Phan J, Sio TT, Nguyen TP, et al. Reirradiation of Head and Neck Cancers With Proton Therapy: Outcomes and Analyses. *Int J Radiat Oncol Biol Phys*. 2016 Sep 1;96(1):30-41.

BRAIN/SKULL BASE

Gordon, K., Gulidov, I., Koryakin, S. et al. Proton therapy with a fixed beamline for skull-base chordomas and chondrosarcomas: outcomes and toxicity. *Radiat Oncol* **16**, 238 (2021). <https://doi.org/10.1186/s13014-021-01961-9>

Kroeze S.G.C, Mackeorang PH, et al. [A Prospective Study on Health-Related Quality of Life and Patient-Reported Outcomes in Adult Brain Tumor Patients Treated with Pencil Beam Scanning Proton Therapy](#). *Cancers (Basel)*. 2021 Oct; 13(19): 4892. doi: 10.3390/cancers13194892

Kimberley SK, Erik F, et, al. [Outcome and Toxicity of Proton Therapy for Vestibular Schwannoma A Cohort Study. *Otology & Neurotology*](#). September 17, 2021. doi: 10.1097/MAO.00000000000003313

Chambrelant I, Eber J, et, al. [Proton Therapy and Gliomas: A Systematic Review. *Radiation*](#) 2021, 1(3), 218-233; <https://doi.org/10.3390/radiation1030019>

M Walser, B Bojaxhiu., et.al. [Clinical Outcome of Sacral Chordoma Patients Treated with Pencil Beam Scanning Proton Therapy. *Clinical Oncol*](#), 2021 Aug 02. Doi: <https://doi.org/10.1016/j.clon.2021.07.012>

Liu, IC., Holtzman, A.L., Rotondo, R.L. *et al.* [Proton therapy for adult medulloblastoma: Acute toxicity and disease control outcomes. *J Neurooncol*](#) (2021).

Mohan R, Liu A Y, et. al. [Proton therapy reduces the likelihood of high-grade radiation-induced lymphopenia in glioblastoma patients: phase II randomized study of protons vs photons. *Neuro-Oncology*](#), Volume 23, Issue 2, February 2021, Pages 284–294.

Scartoni D, Amelio D, Palumbo P, et. al. [Proton therapy re-irradiation preserves health-related quality of life in large recurrent glioblastoma. *J Cancer Res Clin Oncol*](#). 2020 Mar 21.

Iannafi A, D'Ippolito E, Riva G, et. al. [Proton and carbon ions radiotherapy in skull base chordomas: a prospective study based on a dual particle and a patient-customized treatment strategy. *Neuro Oncol*](#). 2020 Mar 20. pii: noaa067.

Stross WC, Malouff TD, Waddle MR, et. al. [Proton beam therapy utilization in adults with primary brain tumors in the United States. *J Clin Neurosci*](#). 2020 Mar 14. pii: S0967-5868(20)30013-8.

M.J. Amsbaugh, E.L. Chang, A. Mahajan, et, al. [Proton Beam Therapy for the Post-Operative Treatment of Skull Base Sarcoma: The Results of Two Phase II Single Arm Protocols. *Int J Radiat Oncol Biol Phys*](#). 2019 Sep 1; 105 (1): S130

C. Lynch, K.G. Petras, W.F. Hartsell, et, al. [Proton Therapy for Craniospinal Radiochemotherapy Reduces Myelotoxicity and Improves Chemotherapy Completion in Adult Medulloblastoma. *Int J Radiat Oncol Biol Phys*](#). 2019 Sep 1; 105 (1): S141-S142

Sakthivel V, Ganesh KM, et. al. [Second malignant neoplasm risk after craniospinal irradiation in X-ray-based techniques compared to proton therapy. *Australas Phys Eng Sci Med*](#). 2019 Feb 6.

Correia D, Terribilini D, et. al. Whole-ventricular irradiation for intracranial germ cell tumors: Dosimetric comparison of pencil beam scanned protons, intensity-modulated radiotherapy and volumetric-modulated arc therapy. Clin Transl Radiat Oncol. 2019 Jan 9;15:53-61.

Mercado CE, Holtzman AL, Rotondo R, Rutenberg MS, Mendenhall WM. Proton therapy for skull base tumors: A review of clinical outcomes for chordomas and chondrosarcomas. Head Neck. 2019 Feb;41(2):536-541.

Adeberg S, Harrabi SB, et. al. Dosimetric Comparison of Proton Radiation Therapy, Volumetric Modulated Arc Therapy, and Three-Dimensional Conformal Radiotherapy Based on Intracranial Tumor Location. Cancers (Basel). 2018 Oct 26;10(11).

Ardenfors O, Dsu A, Lillhök J, et. al. Out-of-field doses from secondary radiation produced in proton therapy and the associated risk of radiation-induced cancer from a brain tumor treatment. Physica Medica: European Journal of Medical Physics. 2018 Sep; 53: 129-136.

Leeman JE, Lee NY, Zhou Y, et. al. Endoscopic Resection Followed by Proton Therapy With Pencil Beam Scanning for Skull Base Tumors. Laryngoscope. 2018 Sep 12.

Murray FR, Snider JW, Bolsi A, et. al. Long-Term Clinical Outcomes of Pencil Beam Scanning Proton Therapy for Benign and Non-benign Intracranial Meningiomas. Int J Radiat Oncol Biol Phys. 2017 Aug 12.

Weber DC, Malyapa R, Albertini F, et. al. Long term outcomes of patients with skull-base low-grade chondrosarcoma and chordoma patients treated with pencil beam scanning proton therapy. Radiother Oncol. 2016 Jul;120(1):169-74.

Holm AIS, Petersen JBB, Muren LP, et. al. Functional image-guided dose escalation in gliomas using of state-of-the-art photon vs. proton therapy. Acta Oncol. 2017 Jun;56(6):826-831.

Geng C, Moteabbed M, Seco J, et. al. Dose assessment for the fetus considering scattered and secondary radiation from photon and proton therapy when treating a brain tumor of the mother. Phys Med Biol. 2016 Jan 21;61(2):683-95.

Adeberg S, Harrabi SB, Bougatf N, et. al. Intensity-modulated proton therapy, volumetric-modulated arc therapy, and 3D conformal radiotherapy in anaplastic astrocytoma and glioblastoma : A dosimetric comparison. Strahlenther Onkol. 2016 Nov;192(11):770-779.

Petr J, Platzek I, Hofheinz F, et. al. Photon vs. proton radiochemotherapy: Effects on brain tissue volume and perfusion. Radiother Oncol. 2018 Jul; 128(1):121-127.

Baumann BC, Lustig RA, Mazzone S, et. al. [A prospective clinical trial of proton therapy for chordoma and chondrosarcoma: Feasibility assessment.](#) *J Surg Oncol.* 2019 Aug; 120(2): 200-205.

Stieb S, Snider JW 3rd, Placidi L, Kliebsch U, Lomax AJ, et. al. [Long-Term Clinical Safety of High-Dose Proton Radiation Therapy Delivered With Pencil Beam Scanning Technique for Extracranial Chordomas and Chondrosarcomas in Adult Patients: Clinical Evidence of Spinal Cord Tolerance.](#) *Int J Radiat Oncol Biol Phys.* 2017 Sep 4.

OCULAR

Marinkovic M, Pors LJ, van den Berg V, et al. [Clinical Outcomes after International Referral of Uveal Melanoma Patients for Proton Therapy.](#) *Cancers (Basel).* 2021;13(24):6241. Published 2021 Dec 13. doi:10.3390/cancers13246241

J. Thariat, J. Salleron, C. Maschi, et. al. [Oncologic and visual outcomes after postoperative proton therapy of localized conjunctival melanomas.](#) *Radiat Oncol.* 2019 Dec 27; 14: 239.

Scholz SL, Héroult J, et. al. [Proton radiotherapy in advanced malignant melanoma of the conjunctiva.](#) *Graefes Arch Clin Exp Ophthalmol.* 2019 Mar 27.

LIVER

R.S. Bhangoo, T.C. Mullikin., et.al. [Intensity Modulated Proton Therapy for Hepatocellular Carcinoma: Initial Clinical Experience.](#) *Adv Radiat Oncol.* 2021 Mar 2;6(4):100675. Doi: 10.1016/j.adro.2021.100675.

M Moteabbed, J Smeets., et.al. [Toward MR-integrated proton therapy: modeling the potential benefits for liver tumors.](#) *Phys Med Biol.* 2021 Aug 18. Doi: 10.1088/1361-6560/ac1ef2.

Iwata H, Ogino H, et.al. [Image-Guided Proton Therapy for Elderly Patients with Hepatocellular Carcinoma: High Local Control and Quality of Life Preservation.](#) *Cancers (Basel).* 2021 Jan; 13(2): 219. doi: [10.3390/cancers13020219](#)

Chuong M, Kaiser A, Molitoris J, et. al. [Proton beam therapy for liver cancers.](#) *J Gastrointest Oncol.* 2020 Feb; 11(1): 157–165.

Shaakir Hasan, Stephen Abel, Vivek Verma. et. al. [Proton beam therapy versus stereotactic body radiotherapy for hepatocellular carcinoma: practice patterns, outcomes, and the effect of biologically effective dose escalation.](#) *J Gastrointest Oncol.* 2019 Oct; 10(5): 999-1009.

Mondlane G, Gubanski M, Lind PA, et. al. Comparative study of the calculated risk of radiation-induced cancer after photon- and proton-beam based radiosurgery of liver metastases. *Phys Med.* 2017 Mar 30.

LUNG AND THORACIC

Bayasgalan U, Moon SH, et al. Dosimetric Comparisons between Proton Beam Therapy and Modern Photon Radiation Techniques for Stage I Non-Small Cell Lung Cancer According to Tumor Location. *Cancers (Basel).* 2021;13(24):6356. Published 2021 Dec 17.
doi:10.3390/cancers13246356

Köthe A, Bizzocchi A, et,al. Investigating the potential of proton therapy for hypoxia-targeted dose escalation in non-small cell lung cancer. *Radiat Oncol.* 2021; 16: 199. Published online 2021 Oct 11. doi: 10.1186/s13014-021-01914-2

Kim N, Noh JM, Lee W, Park B, Pyo H. Clinical Outcomes of Pencil Beam Scanning Proton Therapy in Locally Advanced Non-Small Cell Lung Cancer: Propensity Score Analysis. *Cancers.* 2021; 13(14):3497. <https://doi.org/10.3390/cancers13143497>.

Nagata I, Ogino T, et, al. Clinical Outcomes of Proton Beam Therapy for Ground-Glass Opacity-Type Lung Cancer. *Lung Cancer (Auckl).* 2020; 11:105-111

P. Mohindra,S. Mossahebi, J.M. Moreau, et, al. First Clinical Experience of Gated Voluntary Breath-Hold Intensity Modulated Proton Therapy for Thoracic Malignancies. *Int J Radiat Oncol Biol Phys.* 2019 Sep 1; 105 (1): S252

Rice SR, Saboury B, et. al. Quantification of global lung inflammation using volumetric 18F-FDG PET/CT parameters in locally advanced non-small-cell lung cancer patients treated with concurrent chemoradiotherapy: a comparison of photon and proton radiation therapy. *Nucl Med Commun.* 2019 Jun;40(6):618-625.

Chen J, Lu JL, et. al. Early stage non-small cell lung cancer treated with pencil beam scanning particle therapy: retrospective analysis of early results on safety and efficacy. *Radiat Oncol.* 2019 Jan 25;14:16.

Kim H, Pyo H, Noh JM, et. al. Preliminary result of definitive radiotherapy in patients with non-small cell lung cancer who have underlying idiopathic pulmonary fibrosis: comparison between X-ray and proton therapy. *Radiat Oncol.* 2019 Jan 28;14(1):19.

Liu C, Sio TT, et. al. Small-spot intensity-modulated proton therapy and volumetric-modulated arc therapies for patients with locally advanced non-small-cell lung cancer: A dosimetric comparative study. *J Appl Clin Med Phys.* 2018 Oct 17.

Huang Q, Jabbour SK, Xiao Z, et. al. Dosimetric feasibility of 4DCT-ventilation imaging guided proton therapy for locally advanced non-small-cell lung cancer. *Radiat Oncol*. 2018 Apr 25;13(1):78.

Lee E, Zeng J, Miyaoka RS, et. al. Functional lung avoidance and response-adaptive escalation (FLARE) RT: Multimodality plan dosimetry of a precision radiation oncology strategy. *Med Phys*. 2017 Jul;44(7):3418-3429.

Ho JC, Nguyen QN, Li H, et. al. Reirradiation of thoracic cancers with intensity modulated proton therapy. *Pract Radiat Oncol*. 2018 Jan - Feb;8(1):58-65.

Diwanji TP, Mohindra P, Vyfhuis M, et. al. Advances in radiotherapy techniques and delivery for non-small cell lung cancer: benefits of intensity-modulated radiation therapy, proton therapy, and stereotactic body radiation therapy. *Transl Lung Cancer Res*. 2017 Apr;6(2):131-147.

Daniel R. Gomez, Andreas Rimner, et.al. The Use of Radiation Therapy for the Treatment of Malignant Pleural Mesothelioma: Expert Opinion from the National Cancer Institute Thoracic Malignancy Steering Committee, International Association for the Study of Lung Cancer, and Mesothelioma Applied ReJ Thorac Oncol. 2019 Jul; 14(7):1172-1183.

LYMPHOMA

Bates JE, Terezakis S, et al. [Comparative Effectiveness of Proton Therapy versus Photon Radiotherapy in Adolescents and Young Adults for Classical Hodgkin Lymphoma](#). *Int J Part Ther* (2021). doi.org/10.14338/IJPT-21-00011.1

Moreno AC, Gunther JR, et. al. [Impact of Deep Inspiration Breath Hold on Normal Tissue Sparing with Intensity-Modulated Radiotherapy versus Proton Therapy for Mediastinal Lymphoma](#). *Advances Radiation Onco*. 2020 Aug 25.

Konig L, Haering P, et. al. Secondary Malignancy Risk Following Proton vs. X-ray Treatment of Mediastinal Malignant Lymphoma: A Comparative Modeling Study of Thoracic Organ-Specific Cancer Risk. *Front Oncol*. 2020 Jul 7.

Scorsetti M, Cozzi L, et. al. Intensity modulated proton therapy compared to volumetric modulated arc therapy in the irradiation of young female patients with hodgkin's lymphoma. Assessment of risk of toxicity and secondary cancer induction. *Radiat Oncol*, 2020 Jan 13.

Ashlyn S Everett, Bardford S Hoppe, Debbie Louis. et. al. [Comparison of Techniques for Involved-Site Radiation Therapy in Patients with Lower Mediastinal Lymphoma.](#) *Pract Radiat Oncol.* 2019 Oct May 22.

Ntentas G, Dedeckova K, et. al. [Clinical intensity-modulated proton therapy for Hodgkin lymphoma: which patients benefit the most?](#) *Pract Radiat Oncol.* 2019 Jan 29. pii: S1879-8500(19)30007-4.

Zeng C, Plastaras J, et. al. [Proton pencil beam scanning for mediastinal lymphoma: treatment planning and robustness assessment](#) *Acta Oncologica* 2016; 55 (9-10).

PANCREAS

Raturi V, Hojo H, et. al. [Radiobiological model-based approach to determine the potential of dose-escalated robust intensity-modulated proton radiotherapy in reducing gastrointestinal toxicity in the treatment of locally advanced unresectable pancreatic cancer of the head.](#) *Radiat Oncol.* 2020 June 22.

Rutenberg M, Nichols R, et. al. [Proton beam radiotherapy for pancreas cancer.](#) *J Gastrointest Oncol.* 2020 Feb; 11(1): 166–175.

Jethwa K, Tryggestad E, et. al. [Initial experience with intensity modulated proton therapy for intact, clinically localized pancreas cancer: Clinical implementation, dosimetric analysis, acute treatment-related adverse events, and patient-reported outcomes.](#) *Advances in Radiation Oncology.* 2018;3(3):314-321.

PEDIATRICS

S Peters, J Merta, L Schmidt, et al. [Evaluation of dose, volume and outcome in children with localized, intracranial ependymoma treated with proton therapy within the prospective KiProReg Study.](#) *Neuro-Oncology*, 2021; noab301, <https://doi.org/10.1093/neuonc/noab301>

Cunningham D, Zaniletti I, et, al. [Lymphopenia in Pediatric Patients Following Proton Radiotherapy.](#) *Int J Radiat Oncol Biol Phys.* Volume 111, Issue 3, Supplement, 1 November 2021, Page e173.doi: <https://doi.org/10.1016/j.ijrobp.2021.07.658>

Upadhyay R, Grosshans D.R, et,al. [Quantifying the Risk and Dosimetric Variables of Symptomatic Brainstem Injury After Proton Beam Radiation in Pediatric Brain Tumors.](#) *Int J Radiat Oncol Biol Phys.* Volume 111, Issue 3, Supplement, 1 November 2021, Pages S82-S83. doi: <https://doi.org/10.1016/j.ijrobp.2021.07.198>

Indelicato DJ, Ioakeim-Ioannidou M, et al. Bicentric Treatment Outcomes following Proton Therapy for Non-Myxopapillary High-Grade Spinal Cord Ependymoma in Children. *Int J Radiat Oncol Biol Phys*. September 28, 2021. doi: <https://doi.org/10.1016/j.ijrobp.2021.09.030>

R Suzuki, H Fukushima, et al. [Proton beam therapy with concurrent chemotherapy is feasible in children with newly diagnosed rhabdomyosarcoma](#). *Rep Pract Oncol Radiother*. 2021 Aug 12;26(4):616-625.

Eaton B.R., Fong G.W., et al. [Intellectual functioning among case-matched cohorts of children treated with proton or photon radiation for standard-risk medulloblastoma](#). *Cancer*. 13 July 2021. doi:10.1002/cncr.33774

Taylor S, Lim P, et al. [Risk of radiation-induced second malignant neoplasms from photon and proton radiotherapy in pediatric abdominal neuroblastoma](#). *Phys Imaging Radiat Oncol*. 2021 Jul 9; 19: 45-52. doi: 10.1016/j.phro.2021.06.003.

Biewald E., Kiefer., et al. [Feasibility of Proton Beam Therapy as a Rescue Therapy in Heavily Pre-Treated Retinoblastoma Eyes](#). *Cancers (Basel)*. 2021 Apr; 13(8): 1862. doi: 10.3390/cancers13081862.

Rombi B, Ruggi A, et al. [Proton therapy: A therapeutic opportunity for aggressive pediatric meningioma](#). *Pediatric Blood & Cancer*, 07 March 2021.

Gallagher KJ, Youssef B, et al. [Proton Radiotherapy Could Reduce the Risk of Fatal Second Cancers for Children with Intracranial Tumors in Low- and Middle-Income Countries](#). *Int J Part Ther* (2021).

Looi WS, Indelicato DJ, Mailhot Vega RB, Morris CG, Sandler E, Aldana PR, Bradley JA. [Outcomes following limited-volume proton therapy for multifocal spinal myxopapillary ependymoma](#). *Pediatr Blood Cancer*. 2020 Nov 23:e28820. doi: 10.1002/pbc.28820. Epub ahead of print. PMID: 33226179.

Sahaja A, Huang C, et al. [Adaptive Proton Therapy for Pediatric Patients: Improving the Quality of the Delivered Plan With On-Treatment MRI](#). *International Journal of Radiation Oncology, Biology, Physics*, October 28, 2020

Yazdi H, Meadows R. [Child Proton Beam Therapy: a qualitative study of parental views on treatment and information sources](#). Surrey Research Insight, 2020.

Boilk N, Hall M, et al. [Psychosocial Support for Pediatric Patients at Proton Therapy Institutions](#). *Int J Part Ther*, 2020

Uezono H, Indelicato D, et. al. Treatment Outcomes Following Proton Therapy for Ewing Sarcoma of the Pelvis. Radiation Oncol. 2020 May 10.

Greenberger BA, Yock TI. The role of proton therapy in pediatric malignancies: Recent advances and future directions. Semin Oncol. 2020 Feb 21. pii: S0093-7754(20)30002-6.

Indelicato D, Rotondo R, et. al. Outcomes following Proton Therapy for Group III Pelvic Rhabdomyosarcoma. Int J Radiat Oncol Biol Phys. 2020 Jan 24.

Sardaro A, Carbonara R, Petruzzelli M, et. al. Proton therapy in the most common pediatric non-central nervous system malignancies: an overview of clinical and dosimetric outcomes. Ital J Pediatr. 2019 Dec 27; 45:170.

H. Kim, T. Kim, J. Jung, et.al. The regression patterns of pediatric optic pathway glioma after Proton Beam Therapy. Int J Radiat Oncol Biol Phys. 2019 Nov 15; 105 (4): E912.

R. Frakulli, S. Nagaraja, T. Steinmeier, et. al. Early ototoxicity in children after craniospinal irradiation using pencil beam proton therapy. Int J Radiat Oncol Biol Phys. 2019 Nov 15; 105 (4): E912.

S.M. Kharod, D.J. Indelicato, R.L. Rotondo, et, al. Outcomes Following Proton Therapy for Ewing Sarcoma of the Cranium and Skull Base. Int J Radiat Oncol Biol Phys. 2019 Sep 1; 105 (1): E635

M. Ioakeim-Ioannidou, K.X. Liu, et, al. A Multi-Institutional Retrospective Comparative Analysis of Proton and Photon Therapy-Induced Hematologic Toxicity in Medulloblastoma Patients. Int J Radiat Oncol Biol Phys. 2019 Sep 1; 105 (1): E625-E626

Hashimoto T, Shimizu S, et. al. Clinical experience of craniospinal intensity-modulated spot-scanning proton therapy using large fields for central nervous system medulloblastomas and germ cell tumors in children, adolescents, and young adults. J Radiation Res. 2019 May 21; pii: rrz022.

Sakthivel V, Ganesh KM, et. al. Second malignant neoplasm risk after craniospinal irradiation in X-ray-based techniques compared to proton therapy. Australas Phys Eng Sci Med. 2019 Feb 6.

Hill-Kayser CE, Tochner Z, et. al. Outcomes after Proton Therapy for Treatment of Pediatric High-Risk Neuroblastoma . Int J Radiat Oncol Biol Phys. 2019 Feb 7. pii: S0360-3016(19)30190-7.

Journy N, Indelicato D, Withrow D, et. al. Patterns of proton therapy use in pediatric cancer management in 2016: An international survey. Radiotherapy and Oncology. 2018. In Press.

Huynh M, Marcu LG, Giles E, et. al. Current status of proton therapy outcome for paediatric cancers of the central nervous system - Analysis of the published literature. Cancer Treat Rev. 2018 Nov;70:272-288.

Arscott WT, Cope C. et. al. Proton Therapy for Management of Pediatric Hodgkin Lymphoma Involving the Mediastinum: Evaluation of Toxicity and Evolution of Therapy Over 7 Years of Experience. Int J Radiat Oncol Biol Phys. 2018 Nov. 102(suppl 3): S53-S54.

Ladra MM, MacDonald SM, Terezakis SA. Proton therapy for central nervous system tumors in children. Pediatr Blood Cancer. 2018 Jul;65(7):e27046.

Pulsifer MB, Duncanson H, Grieco J, et al. Cognitive and Adaptive Outcomes Following Proton Radiation for Pediatric Patients with Brain Tumors. Int J Radiat Oncol Biol Phys. 2018.

Haas-Kogan D, Indelicato D, Paganetti H, et. al. National Cancer Institute Workshop on Proton Therapy for Children: Considerations Regarding Brainstem Injury. Int J Radiat Oncol Biol Phys. 2018 May 1;101(1):152-168.

Bojaxhiu B, Ahlhelm F, Walser M, et. al. Radiation Necrosis and White Matter Lesions in Pediatric Patients With Brain Tumors Treated With Pencil Beam Scanning Proton Therapy. Int J Radiat Oncol Biol Phys. 2018 Mar 15;100(4):987-996.

Vogel J, Both S, Kirk M, et al. Proton therapy for pediatric head and neck malignancies. Pediatr Blood Cancer. 2017;00: e26858.

Vogel, J., Lin, H., Both, S., et. al. Pencil beam scanning proton therapy for treatment of the retroperitoneum after nephrectomy for Wilms tumor: A dosimetric comparison study. Pediatr Blood Cancer. 2017, 64: 39–45.

Farace P, Bizzocchi N, Righetto R, et. al. Supine craniospinal irradiation in pediatric patients by proton pencil beam scanning. Radiother Oncol. 2017 Apr;123(1):112-118.

Giantsoudi D, Seco J, Eaton BR, et. al. Evaluating Intensity Modulated Proton Therapy Relative to Passive Scattering Proton Therapy for Increased Vertebral Column Sparing in Craniospinal Irradiation in Growing Pediatric Patients. Int J Radiat Oncol Biol Phys. 2017 May 1;98(1):37-46.

Weber DC, Murray FR, Correia D, et. al. Pencil beam scanned protons for the treatment of patients with Ewing sarcoma. Pediatr Blood Cancer. 2017 Dec;64(12).

Leiser D, Calaminus G, Malyapa R, et. al. Tumour control and Quality of Life in children with rhabdomyosarcoma treated with pencil beam scanning proton therapy. Radiother Oncol. 2016 Jul;120(1):163-8.

Ares C, Albertini F, Frei-Welte M, et. al. Pencil beam scanning proton therapy for pediatric intracranial ependymoma. J Neurooncol. 2016 May;128(1):137-45.

Geng C, Moteabbed M, Xie Y, et. al. Assessing the radiation-induced second cancer risk in proton therapy for pediatric brain tumors: the impact of employing a patient-specific aperture in pencil beam scanning. *Phys Med Biol.* 2016 Jan 7;61(1):12-22.

Doyen J, Jazmati D, Geismar D, et. al. Outcome and patterns of relapse in childhood parameningeal rhabdomyosarcoma treated with proton beam therapy. *Int J Radiat Oncol Biol Phys.* 2019 Aug 13

PROSTATE

Yoshimura T, Nishioka K, et, al. A treatment planning study of urethra-sparing intensity-modulated proton therapy for localized prostate cancer. *Int J Radiat Oncol Biol Phys.* Volume 20, October 2021, Pages 23-29. doi: <https://doi.org/10.1016/j.phro.2021.09.006>

Bryant M. C., Henderson H. R., et.al. Consensus Statement on Proton Therapy for Prostate Cancer. *Int J Part Ther* (2021); doi: 10.14338/IJPT-20-00031.

Dutz A, Agolli L, et. al. Early and late side effects, dosimetric parameters and quality of life after proton beam therapy and IMRT for prostate cancer: a matched-pair analysis. *Acta Oncol.* 2019 Mar 18:1-10.

Wang CJ, Guarisco. Prospective Safety and Patient-Reported Quality-of-Life Outcome for Prostate Cancer Treated with Image-Guided Compact Pencil-Beam Proton Unit. *Int J Radiat Oncol Biol Phys.* 2018 Nov. 102(suppl 3): e148.

Ong A, Ang, KW, et. al. Intensity-modulated radiotherapy for whole pelvis irradiation in prostate cancer: A dosimetric and plan robustness study between photons and protons. *Technical Innovations & Patient Support in Radiation Oncology.* 2018;6:11-19.

Lee H, Macomber M, et. al. Early toxicity and patient reported quality-of-life in patients receiving proton therapy for localized prostate cancer: a single institutional review of prospectively recorded outcomes. *Radiation Oncology.* 2018;13(1):1-9.

Takagi M, Demizu Y, et. al. Long-term outcomes in patients treated with proton therapy for localized prostate cancer *Cancer Med.* 2017 Oct; 6(10): 2234–2243.

Bryant C, Smith T, et al. Five-Year Biochemical Results, Toxicity, and Patient-Reported Quality of Life After Delivery of Dose-Escalated Image Guided Proton Therapy for Prostate Cancer. *Int J Radiat Oncol Biol Phys.* 2016 May; 95(1): 422-434.

RECTAL

M.Fok, S. Toh, J.E. Maducolil, et al. Proton Beam Therapy in Rectal Cancer: A Systematic Review and Meta-Analysis *British Journal of Surgery*, Volume 108, Issue Supplement_2, May 2021, znab135.020, <https://doi.org/10.1093/bjs/znab135.020>

Koroulakis A, Molitoris J, Kaiser A, et, al. RE-IRRADIATION FOR RECTAL CANCER USING PENCIL-BEAM SCANNING PROTON THERAPY: A SINGLE INSTITUTIONAL EXPERIENCE, *Advances in Radiation Oncology*. 2020 Oct 14.

Vaios E, Wo J, et. al. Proton beam radiotherapy for anal and rectal cancers. *J Gastrointest Oncol*. 2020 Feb; 11(1): 176–186.

Blanco Kiely JP, White BM. Robust Proton Pencil Beam Scanning Treatment Planning for Rectal Cancer Radiation Therapy. *Int J Radiat Oncol Biol Phys*. 2016 May 1;95(1):208-15.

SPINE

Snider JW, Schneider RA, Poelma-Tap D, et. al. Long-Term Outcomes and Prognostic Factors After Pencil-Beam Scanning Proton Radiation Therapy for Spinal Chordomas: A Large, Single-Institution Cohort. *Int J Radiat Oncol Biol Phys*. 2018 May 1;101(1):226-233.

Stieb S, Snider JW 3rd, Placidi L, Kliebsch U, Lomax AJ, et. al. Long-Term Clinical Safety of High-Dose Proton Radiation Therapy Delivered With Pencil Beam Scanning Technique for Extracranial Chordomas and Chondrosarcomas in Adult Patients: Clinical Evidence of Spinal Cord Tolerance. *Int J Radiat Oncol Biol Phys*. 2017 Sep 4.

Baumann BC, Lustig RA, Mazzone S, et. al. A prospective clinical trial of proton therapy for chordoma and chondrosarcoma: Feasibility assessment. *J Surg Oncol*. 2019 Aug; 120(2): 200-205.

PROTON THERAPY AND IMMUNOTHERAPY

Wang Y, Deng W, Li N, et al. Combining Immunotherapy and Radiotherapy for Cancer Treatment: Current Challenges and Future Directions. *Front Pharmacol*. 2018;9:185.

Zhang H, Chen J. Current status and future directions of cancer immunotherapy. *J Cancer* 2018; 9(10):1773-1781.

Lee HJ, Zeng J, Rengan R. Proton beam therapy and immunotherapy: an emerging partnership for immune activation in non-small cell lung cancer. *Transl Lung Cancer Res*. 2018;7(2):180-188.

UPPER GASTROINTESTINAL

Moon SH, Suh Y. [The Role of Modern Radiotherapy Technology in the Treatment of Esophageal Cancer.](#) Korean J Thorac Cardiovasc Surg. 2020 Aug 5; 53(4): 184 -190.

Jethwa KR, Haddock MG, et, al. [The emerging role of proton therapy for esophagus cancer.](#) J Gastrointest Oncol. 2020 Feb;11(1):144-156.

Lin SH, Hobbs BP, Verma V, et, al. [Randomized Phase IIB Trial of Proton Beam Therapy Versus Intensity-Modulated Radiation Therapy for Locally Advanced Esophageal Cancer.](#) J Clin Oncol. 2020 Mar 11:JCO1902503.

DeCesaris CM, McCarroll R, Mishra MV, et. al. [Assessing Outcomes of Patients Treated with Re-irradiation Utilizing Proton Pencil-Beam Scanning for Primary or Recurrent Malignancies of the Esophagus and Gastroesophageal Junction.](#) J Thorac Oncol. 2020 Mar 4. pii: S1556-0864(20)30144-1.

Celik E, Baus W, et. al. [Volumetric modulated arc therapy versus intensity-modulated proton therapy in neoadjuvant irradiation of locally advanced oesophageal cancer.](#) Radiation Oncol. 2020 May 24.

Patel S, Edgington S. et. al. [Novel use of proton beam therapy for neoadjuvant treatment of radiation-associated squamous cell carcinoma of the esophagus.](#) J Gastrointest Cancer. 2019 Feb;10(1):155-160.

Beltran C, Schultz HL, et. al. [Radiation biology considerations of proton therapy for gastrointestinal cancers.](#) J Gastrointest Oncol. 2020 Feb; 11(1):225-230.

Barsky AR, Reddy VK, Plastaras JP, et. al. [Proton beam re-irradiation for gastrointestinal malignancies: a systematic review.](#) J Gastrointest Oncol. 2020 Feb; 11(1):187-202.

Liu C, Bhangoo RS, et. al. [Dosimetric comparison of distal esophageal carcinoma plans for patients treated with small-spot intensity-modulated proton versus volumetric-modulated arc therapies.](#) J Appl Clin Med Phys. 2019 May 21; 257(6):1309-1318.

RENAL

FUKUMITSU N, ISHIKAWA H, et, al. [Proton Therapy for Primary Renal Cell Carcinoma: The First Nationwide Retrospective Study in Japan.](#) *International Journal of Experimental and Clinical Pathophysiology and Drug Research.* 2020 Jun 29.