

MD Anderson Cancer Center offers next evolution of cancer treatment with intensity modulated proton therapy

New technological capabilities further refine radiation therapy options for complicated head and neck tumors

Selected for its ability to target tumors precisely while minimizing damage to healthy surrounding tissue, proton therapy has rapidly gained a foothold as an option for radiation treatment in the past decade. The [Proton Therapy Center](#) at [The University of Texas MD Anderson Cancer Center](#) in Houston, Texas, continues to innovate the field by being the first and only center in North America to treat patients with the most advanced form of proton therapy, called intensity modulated proton therapy with multi-field optimization (IMPT). Opened in 2006 as the first proton therapy center at a major comprehensive cancer center, it is now one of 10 proton therapy centers currently operating in the United States. The Proton Therapy Center treats over 800 patients of all ages every year.

IMPT, considered the “holy grail” by many radiation oncologists, is best used to deliver a potent and precise dose of protons to the most complicated tumors, ones that largely reside embedded in the nooks and crannies of the head and neck or skull base. MD Anderson envisioned IMPT as an achievable reality when the Proton Therapy Center introduced [pencil beam technology](#) in 2008 for patients with cancers of the pelvis, brain and certain pediatric tumors. Like pencil beam, IMPT relies on complex treatment planning systems and an intricate network of magnets to focus and aim a narrow proton beam and essentially “paint” the radiation dose onto the tumor layer by layer. Both modalities differ from traditional, passively scattered proton therapy, in that neither requires additional shaping devices, also known as apertures and compensators, to conform the proton beam to the patient’s tumor.

“In under a decade, MD Anderson has established a full spectrum of proton therapy techniques, providing a range of options from which to select the best radiation treatment matched to a patient’s tumor,” says [Steven J. Frank, M.D.](#), associate professor in MD Anderson’s Department of Radiation Oncology and director of Advanced Technologies at the Proton Therapy Center. “With IMPT, radiation oncologists can offer the precision and tissue-sparing capabilities of proton therapy to patients with the most complicated tumors of the head and neck.”

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Proton Therapy at MD Anderson			
Type of Proton Therapy	Year of First Patient	Conditions Treated at MD Anderson	Number of Patients Treated
Fixed beam	2006	Prostate	1,039
3D-conformal, passively scattered	2006	Brain & skull-based, breast, esophageal, head & neck, liver, lung, lymphoma, pediatric tumors, prostate and sarcomas	3,335
Pencil beam, actively scattered with single field optimization	2008	Cancers of the pelvis, brain/base of skull and certain pediatric tumors	894
IMPT, actively scattered with multi-field optimization	2010	Complicated head and neck tumors	70

SOURCE: THE UNIVERSITY OF TEXAS MD ANDERSON CANCER CENTER.

Most advanced agility to target exact tumor location

IMPT enhances the ability of the pencil beam to treat the tumor from multiple angles, at various depths and degrees of intensity. While each treatment field generated in pencil beam covers the entire area of the tumor, true IMPT patches together fields that treat one portion of the target area at a time until the entire tumor is treated. The MD Anderson Proton Therapy Center has pioneered this multi-field optimization strategy and is currently the only center in North America to offer this advanced capability. This distinction allows for more precise dose distribution in which very specific amounts of radiation can be given across the peaks and valleys of the tumor. Increased dosing is calculated for regions that need it most while areas that can be spared, such as those near critical structures like the brain stem, receive a lower dose.

“In the era of personalized medicine, IMPT is a type of radiation so sophisticated that we can adjust it to a patient’s specific tumor with unique precision,” Dr. Frank says. “It’s especially well-suited for patients with complicated tumor shapes nestled in the head and neck region where you want to retain key functions such as vision, speech, swallowing and taste.”

MD Anderson has treated more than 70 patients with IMPT to date.

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Protecting quality of life; reducing side effects

In 2010, the first patient treated at MD Anderson with IMPT was an individual who had a cancerous mass wrapped precariously around the base of the brain stem. After considering options with Dr. Frank, the patient chose to move forward with IMPT as the best chance to eliminate the cancer while also maintaining a career and being an engaged parent. The patient completed treatment in January 2011 and experienced a complete response to the IMPT and chemotherapy regimen recommended by the treatment team.

Like this patient, many ideal IMPT cases involve tumors that lay behind critical structures of the head and neck. Since this case, Dr. Frank and his team have treated cancers of the nasal and sinus cavities; the oral cavity, including the salivary glands, tongue and tonsils; the larynx; the eye; and others at the base of the skull and spine. Because the protons' powerful energy can be largely confined to the cancerous tissue, motor function, vision and other quality of life factors, such as the senses of smell and taste and swallowing, remain virtually untouched.

The need to implant a feeding tube during head and neck treatment – which can occur in up to 60% of standard radiation patients – may be avoided in IMPT patients due to less collateral damage to normal swallowing structures, such as the oral cavity. Side effects such as nausea and loss of taste are also reduced with proton therapy. This enables patients to better maintain their weight and hydration, contributing to more successful treatment outcomes and substantially improving their quality of life during and after cancer treatment.

Treating the youngest patients

Many of the quality of life benefits afforded by IMPT are also appealing to pediatric patients whose bodies are still developing. The Proton Therapy Center treats over 120 children annually and has seen nearly 600 pediatric patients since opening in 2006.

More Than a Machine

When Gerry McKim was diagnosed with oropharynx squamous cell carcinoma – a cancer of the throat and neck that had spread to the back of his tongue and the lymph nodes in his neck – he knew one thing for sure: he had to do his research on the best possible treatment for him.

In March 2011, McKim's research led him to the MD Anderson Proton Therapy Center and to Steven Frank, M.D., associate professor in the Department of Radiation Oncology. Assessing his case, Dr. Frank and the treatment team recommended McKim to be the first oropharynx patient for IMPT.

A retired Navy pilot who lost his wife to ovarian cancer in 2005, McKim was not interested in slowing down his life or curtailing his special interest in traveling abroad. But he knew he had to take his cancer treatment seriously. "For the first time in my life I gave up control and I completely trusted Dr. Frank with my life when I agreed to undergo IMPT for my cancer," says McKim. "From the nurses who I taught to two-step in the treatment room to the physicist who grew up in an area of China I served in, everyone was fully invested in ensuring we beat the disease and seeing that my life after cancer allowed me to do the activities I love like eating out with friends and traveling."

Today, McKim is cancer-free in Tampa, FL. To read more of Gerry's story click [here](#).

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[Anita Mahajan, M.D.](#), medical director of the Proton Therapy Center and director of Pediatric Radiation Oncology in MD Anderson’s Department of Radiation Oncology, primarily uses IMPT to treat children presenting with complex, irregularly shaped tumors of the head and neck, spine or pelvis. Perhaps the most profound benefit of IMPT for young patients is the ability to precisely conform high doses of radiation around complex structures including the brain and brain stem thus reducing the amount of radiation administered to these healthy, sensitive areas.

“In adults we are mostly concerned about making the high-dose areas precise. In children the low-dose areas are just as important. Even a low-dose of radiation delivered to the brain could cause damage in a child,” says Dr. Mahajan. “Our goal is to use the unparalleled ability to shape the treatment beam to limit serious long-term side effects so our young patients can go on to live happy, healthy lives.”

Children as young as infants are candidates for proton therapy at MD Anderson. Pediatric patients benefit from the same advanced technology available to MD Anderson’s adult patients. IMPT is an attractive option for children whose bodies are still developing and more sensitive to the adverse side effects of radiation therapy.



Since MD Anderson’s Proton Therapy Center opened,

Nearly 600 children have been treated with proton therapy.

A growing number, including Sofia Carlo (pictured left ringing the gong to celebrate the completion of treatment) have received IMPT.

SOURCE: THE UNIVERSITY OF TEXAS MD ANDERSON CANCER CENTER

Ensuring quality with sophisticated computer-based treatment planning

Advanced computing power is a critical component behind the precision and efficacy of IMPT. To create a treatment plan, the radiation oncologist works closely with the Center’s radiologists, physicists and dosimetrists to chart out the best treatment approach – from imaging the patient’s tumor and mapping out the tumor’s shape down to the specific angles and energies needed.

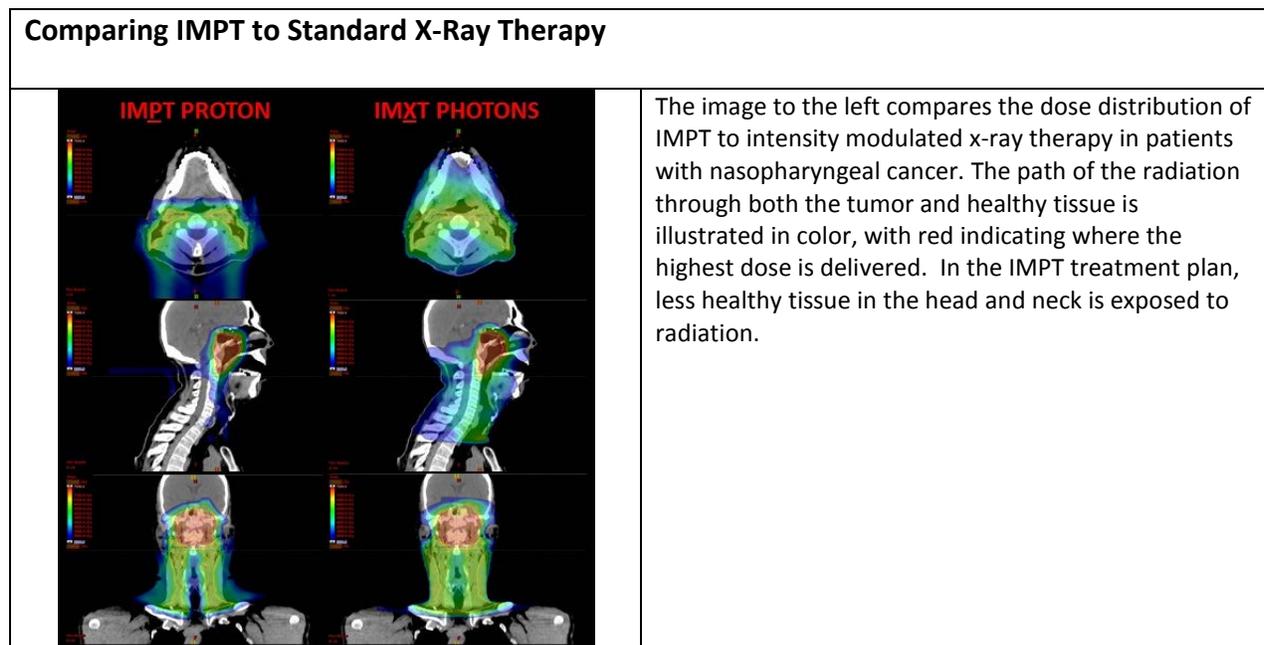
The treatment planning software then distills this information with intricate algorithms to instruct the proton-generating machines to produce beams of the prescribed energies and then direct the magnets to deflect the beam to the pinpointed location on the patient. Additional quality assurance steps are taken to ensure that the computer simulation is replicated in actual results as well.

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“Our team of specialists take the necessary time needed on the front end in order to make sure we know exactly where the beam is directed, how it should be tilted and to confirm the optimal position for the patient,” says [Richard Amos, MSc](#), senior medical physicist at the Proton Therapy Center.

In some cases it can take up to a week for the treatment team to create an individualized IMPT plan. While this takes much longer than the plan needed for passively scattered proton therapy, time is saved at the time of treatment because there is no need to construct beam-shaping apertures and compensators.



SOURCE: THE UNIVERSITY OF TEXAS MD ANDERSON CANCER CENTER

When a patient comes in for treatment, several additional considerations are essential to executing a treatment as planned. Anatomical changes to the tumor size, the surrounding tissue, or the patient’s weight can significantly impact the tumor location and thus affect the treatment plan. To check for any changes of this nature, patients receive verification CT scans during IMPT treatment at the Proton Therapy Center. In situations where significant variations since the original imaging have occurred, the treatment plan is adapted, adding yet another dimension to the personalized approach to each patient’s care.

Advancing the science of IMPT

Through the institution’s clinical trial program and partnerships with outside organizations that specialize in computational science, MD Anderson is also addressing the current limitations and challenges of IMPT to put forth the first body of evidence-based research on its use in cancer patients and lead the way in advancing the technology.

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A collaboration established in 2009 with [Rice University](#), another world-renowned scientific powerhouse based in Houston, aims to apply recent advances in computational science and mathematics to IMPT to develop tools that improve on the efficiency and accuracy of the modality. Continuous two-way communication and close working relationships with the Proton Therapy Center's treatment planning team produces real-time adjustments, further fine-tuning IMPT delivery.

Other research teams are examining how nanotechnology combined with IMPT might someday offer a powerful one-two punch to the tumor. "In the future, a patient might be injected with nanoparticles carrying additional therapy prior to receiving treatment," Amos says. "Using particles sensitive to radiation and programmed to track down the patient's tumor, we could feasibly deposit a very local secondary dose of treatment when activated by the IMPT beam."

This ongoing research at the Proton Therapy Center not only benefits patients receiving treatment at MD Anderson, but also provides an evolving body of knowledge, offering best practices in IMPT as others in the field look to adopt and integrate this new form of radiation therapy.

Leading the way for patients

"As we expand our understanding and use of IMPT, one can imagine this will be the preferred radiation method for patients with the most complicated tumors," Dr. Frank says. "Whether a patient is best suited for conventional radiation therapy, proton therapy or this most advanced form of proton therapy, our goal at MD Anderson is to provide the patient with technology that offers the best possible outcome against their cancer."

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