Defining the future of radiation medicine: where technology meets cancer care

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Introduction

Huge strides in screening and diagnosis of cancer, combined with a multi-disciplinary approach, have led to earlier disease detection and made significant improvements to the overall mortality rate. This is supported by evidence from several randomized controlled trials which have demonstrated that mammography reduces breast cancer mortality by 30 percent.¹

The World Health Organization (WHO) expects cancer incidence to increase by 50 percent by 2020.²

However, 12.5 percent of all deaths worldwide are still caused by cancer, exceeding the percentage of deaths caused by HIV/AIDS, tuberculosis, and malaria combined.² In 2007 alone, over 5.4 million new cases of cancer were diagnosed in economically developed countries³ and globally, 7.6 million people died.⁴ The incidence of the four most common cancers, prostate, colorectal, breast and lung cancers, in total, represents between 32 percent and 41 percent of these new incidences.³ Also, the prevalence of these cancers, as well as many others, continues to rise (Figure 1). In the US⁵ and the UK⁶ cancer is projected to overtake cardiovascular disease as the leading killer, and the World Health Organization (WHO) expects cancer incidence to increase by 50 percent by 2020.⁷ While there have been significant advances in screening, diagnosis and treatment, cancer is a growing problem and researchers the world over are continually developing new ways of tackling this disease.

Defining the present

The current aim of treatment in the efforts against cancer can be viewed as achieving either a palliative goal, relieving symptoms where a cure is not possible; or a curative goal, where the tumor is no longer detectable. In most cases, conventional surgery is the first line of treatment for the majority of solid tumors and may be curative if the tumor has not metastasized. Radiation therapy is the use of ionizing radiation to treat cancers, and radiosurgery is an extremely precise method of delivering radiation doses to destroy tumors and other malformations. Both may be used as first-line therapies, but are more often combined with other treatment methods (Figure 2). These commonly include chemotherapeutic agents (commonly known as ‘chemotherapy’) — cytotoxic drugs used to treat neoplastic disease (alkylating agents, antimetabolites, and natural products), and other pharmaceutical treatments. Over the past five to ten years, there has been a move towards more targeted pharmaceutical therapy, with monoclonal antibody-based drugs, such as bevacizumab and imatinib, which target cancer cells and inhibit elements of their cellular machinery.

Today, advances in imaging and computing power have made radiation therapy and radiosurgery immensely precise and powerful tools.

Summary

- Cancer treatment:
  - palliative
  - curative

- Options:
  - surgery
  - radiotherapy/radiosurgery
  - chemotherapy
  - targeted drugs
These pharmaceutical advances have received a great deal of clinical and public attention, yet this is not the only area where significant advances have been made. The exciting new technology of image guided computer-controlled radiation therapy is now adding the ‘Star Trek’ world of knifeless surgery to the oncologist’s and neurosurgeon’s toolkit. Today, advances in imaging and computing power have made radiation therapy and radiosurgery immensely precise and powerful tools in the struggle against cancer, and one where they are set to play an ever increasing and pivotal role.

**Milestones in radiation therapy and radiosurgery**

For more than 100 years, radiation therapy has been used as a treatment for cancer, after the discovery of X-rays in 1895. The radioactive element radium was employed until the middle of the 20th century when cesium and cobalt came into use. From 1948 – 1953 the first practical device to deliver X-ray radiation as a therapy for tumors and other disorders was developed — the medical linear accelerator (commonly known as a linac). Radiation therapy in the early 1950s, known as two dimensional radiation therapy, consisted of a single beam of radiation irradiating the patient from several directions (non-isocentric), mainly front, back and either side, with, what would be viewed today as very poor precision.

The clinical benefit of radiation therapy relies on the delivery of therapeutic doses of radiation to the tumor volume, while minimizing the radiation dose to healthy tissues and structures and consequent undesired toxicity.
the tumor in its true nature (three-dimensions). A significant step forward was taken with the addition of an extra dimension to CT, allowing oncologists to visualize tumors and surrounding critical structures in 3D. The advent of diagnostic 3D CT permitted the development of 3D conformal radiation therapy in which the radiation beam used to treat the patient could then be shaped to match the tumor volume using a device known as a multileaf collimator (Figure 3). This device is composed of individual ‘leaves’ of a high density material (usually tungsten), that can move independently in and out of the path of a beam in order to shape it to the tumor in 3D. Use of other imaging technologies such as magnetic resonance imaging (MRI) and positron emission tomography (PET) have further refined the ability to define both the tumor and the surrounding tissue.

FIGURE 3. The multileaf collimator — a series of fine tungsten leaves which enable the beam of radiation from a linear accelerator to conform to the shape of the target tumor, reducing the exposure to healthy tissue

Summary

• Radiation therapy has been used to treat cancer for > 100 years
• First patient treated with a linac in 1953
• Useful radiation therapy requires an image of the tumor to guide where to apply it
• Computed tomography enabled high-quality imaging
• Leksell Gamma Knife® launched in 1968, becoming commercially available in 1986
• Computerization has led to great leaps in radiation therapy/radiosurgery and is now an invaluable tool
• Patients can look forward to:
  – reduced risk of side effects
  – better quality of life
  – a hope for cure for many types of tumors

To further reduce the toxicity, the total radiation dose is typically divided into multiple sessions (termed fractionation). As such, there is a need to repeatedly place the radiation beam accurately and reproducibly on the tumor volume. This has been achieved through a variety of guidance techniques. In the early days of radiation therapy, guidance was limited to the fairly crude technique of skin marking or projecting light beams as cross-hairs onto the patient. These techniques, however, reveal no information regarding the size, shape and exact location of the tumor. In addition, between fractions, the tumor may change in all three of these parameters, making accurate and efficacious dose placement exceedingly difficult. Cumulative inappropriate dosing of healthy surrounding tissues leads to toxicity and even potential secondary malignancies.

Treatment planning is the process used to define the incident angles, shapes and intensities of the radiation beams used to irradiate the tumor. The development of two-dimensional computed tomography (CT) enabled radiation oncologists and neurosurgeons to directly visualize tumors. With these early treatment planning systems, the ability to define the tumor using only two-dimensional images was limited and it was impossible to visualize

From a clinical viewpoint, advances in imaging such as CT have resulted in better tumor control in prostate cancer and preservation of saliva after irradiation for head and neck cancer.

In parallel with the great developments in imaging technology and radiation technologies in the 1950s, Prof. Lars Leksell, a Swedish neurosurgeon who was concerned by the staggering 50 – 60 percent mortality rate for patients undergoing brain surgery, recognized the potential of focused radiation for improving outcomes. After evaluating both proton
and linear accelerator technologies, Leksell devised a unique technology that employs gamma rays from multiple cobalt sources to irradiate targets within the cranium with great precision, by integrating radiation with stereotactic guiding devices. From Leksell’s work, two techniques have emerged: stereotactic radiosurgery and stereotactic radiotherapy. Stereotactic radiosurgery refers to treatment that is delivered in one session, while stereotactic radiotherapy refers to treatment delivered in multiple sessions over a period of time. He continually refined his techniques, eventually yielding the first prototype for clinical research of Leksell Gamma Knife® in 1968; continual improvements saw the development of the first commercially available model in 1986. This radiosurgical tool provides an unparalleled means of treating brain tumors with ultra-high precision and without needing to open the skull (Figure 4).

**FIGURE 4. Leksell Gamma Knife® — 201 gamma-ray sources are positioned around the patient’s head. The individual rays are low dose but they all converge on the target to deliver a high dose with sub-millimeter accuracy**

Stereotactic radiosurgery
Stereotactic radiosurgery with Leksell Gamma Knife is a bloodless surgery for neurological diseases. The surgery does not require the skull to be opened for performance of the operation. The patient is treated in one session and can normally return home shortly after treatment.

The method facilitates treatment of very small targets deep within the brain.

The radioactive beams are focused on the target in the brain with extremely high precision and without damaging healthy tissue.

The advances in radiosurgery in the last 50 years have helped to spur the evolution of radiation therapy in general. Advances in hardware have allowed for the more efficient and more accurate delivery of radiation deep into the bodies of cancer patients. The digitization of linear accelerators has been fundamental in allowing more recent advances, including the way in which 3D treatment planning and imaging are used to enhance patient treatment, utilizing intensity modulated radiation therapy (IMRT) (see summary box, page 6) and the automation of beam shaping to accurately match tumor volumes.

The advances in radiosurgery in the last 50 years helped to spur the evolution of radiation therapy in general

It has been estimated that digitization has increased the speed of delivery of IMRT by as much as 30 percent. Not only do these new technologies allow astonishing precision and efficiency, but they are also more robust and cost-effective than their predecessors. With increased reliability, treatment plans can be delivered without unplanned breaks between fractions. From the patient’s perspective this means less wait time between treatment sessions, and a more rapid, safe and effective treatment. From a clinical perspective, it ensures that the tumor is treated aggressively and reduces the risk of tumor movement or growth between gaps in sessions.

Radiation therapy and radiosurgery in current cancer care allow patients to look forward to a better quality of life, increased longevity, and in some cases to a cure — a significant improvement over the last 50 years

The precision and safety of modern radiation medicine make it an invaluable tool in oncological and neurosurgical treatment strategies. From a purely technological point of view the advances in radiation therapy and radiosurgery are remarkable (Figure 5), but what do these improvements in precision and safety mean clinically? All of these improvements have, in a number of cancers, been shown to translate into better outcomes. Radiation therapy and radiosurgery, in current cancer care, allow patients to look forward to a better quality of life, increased longevity, and in some cases to a cure — a significant improvement over the last 50 years.
The state of the art

Linear accelerators are the standard of care in radiation therapy, and certain key innovations have enabled huge leaps in their precision and efficiency, in particular:

- The incorporation of imaging devices on digital linacs to more accurately locate tumors and plan and deliver radiation doses
- The use of 3D volume imaging to help visualize a tumor in true 3D
- Shaping and conforming the intensity of radiation therapy enabling the delivery of higher doses to the target tumor area, and reducing unnecessary radiation to the surrounding healthy tissues
- An optimum 3D dose distribution delivered quickly and accurately to increase the target dose at the same time as reducing the dose to healthy tissue.

First and foremost of these is the combination of linear accelerators and imaging devices to provide huge improvements in effectiveness and safety. This has also paved the way for changing the way in which radiation therapy centers treat and manage the treatment of their patients. At the present time all imaging critical to the accurate delivery of radiation therapy is digitally-based (CT, MRI, PET etc). The ability to acquire and analyze this kind of data within high-

Summary

- Several, key advances have allowed considerable improvements in the accuracy and effectiveness of linear accelerators:
  - **3D volume imaging.** This technology enables visualization of soft tissue detail in any area of the body
  - **IGRT (Image guided radiation therapy).** The integration of tumor imaging into radiation therapy enabling accurate delivery of radiation through on-line 3D volume imaging
  - **IMRT (Intensity modulated radiation therapy).** A method of accurately modulating the radiation intensity to areas of the tumor
  - **VMAT (Volumetric modulated arc therapy).** Rapidly delivers radiation in arcs, whose intensity can be continuously modulated without switching the beam off
speed computer systems, matching the image to dose planning and radiation delivery is known as image guided radiation therapy (IGRT). This is a direct result of the realization that the image guidance technology employed in highly accurate brain, and head and neck radiation therapy can be applied to tumors in the rest of the body including the spine, lung, liver, pancreas and prostate. IGRT consists of the following linear steps:

• 3D CT/MR imaging to visualize the tumor volume prior to treatment
• Treatment planning using these CT/MR images
• 3D imaging to visualize the tumor volume at the time of treatment
• Correction of tumor position
• Delivery of a targeted and precise radiation therapy dose.

However, the very nature of this linear approach does not take into account changes in tumor location or shape during the treatment process. Revolutionary technologies such as Elekta Synergy® (Figure 6) allow 3D guidance at the time of treatment, thus resulting in greatly increased accuracy and shorter total treatment times. The entire treatment strategy from planning to delivery can be easily controlled from a single workstation supported by an electronic medical record (EMR) centered workflow (a paperless, digitally managed approach to imaging and treating the tumor). This has revolutionized what was a separate and serial planning and treatment process (from imaging, to treatment planning, then treatment). Now, terabytes of patient data in the form of tumor images can be sent directly to the linac from an external database, allowing the more effective integration of correcting, planning and treating. This approach has the advantage of being able to adjust, and correct for misalignment of patient, tumor position, shaping and placement of the radiation beam. The development of image guided technologies has been effected through long term collaborations between leading clinical centers and industry. As a result, linac solutions such as Elekta Synergy® represent the state-of-the-art in IGRT and it is thought this innovation can benefit at least 25 – 35 percent of radiation therapy patients.

Essential to the application of IGRT in a clinical setting is the accurate and rapid visualization of tumors in three dimensions. A pioneering technique in this field is 3D volume imaging, developed by Elekta (see summary box, page 6). This technique can acquire true volumetric imaging by directly visualizing the tumor in three dimensions with soft tissue contrast, rather than constructing a three dimensional image from 2D slices of the target area. This has been successfully integrated with linacs allowing a direct comparison with images taken pre-treatment and corrections to treatment planning during the fraction. 3D volume imaging has improved the speed of IGRT and its precision and safety, especially for the treatment of tumors in close proximity to critical body structures. Clinically, 3D volume imaging allows visualization of soft tissues in the thorax and brain, and even the prostate, which is normally very difficult to visualize due to its position. As these tumors move and change shape, direct visualization is required. The alternative is to surgically implant markers (typically made of a high density material such as gold) to represent the shape and location of the tumor. Clearly this is not as accurate a measure of the
position and 3D volume of the tumor. IGRT enables the tumor to be visualized, information which is then used to modulate the shape and intensity of the radiation beam itself with the computer-controlled multileaf collimators. This technique, termed intensity modulated radiation therapy (IMRT) (see summary box, page 6), is an evolution of 3D conformal radiation therapy which enables variations in the dose intensity and beam shape to match the tumor volume. This ‘dose painting’ technique means that many fields are delivered through many angles, further reducing irradiation of the surrounding healthy tissues. Critically, IMRT is highly effective at generating high dose volumes that are concave in shape, sparing normal tissues that intimately surround or are surrounded by the tumor (especially for prostate and spinal cancers). IMRT is particularly important in the treatment of tumors which are hypoxic. A tumor may become hypoxic as the unchecked proliferation of cancer cells outstrips the blood supply to it. These tumors are difficult to treat, as the lack of oxygen reduces the formation of destructive free radicals required for irreparable cellular damage during radiation therapy. IMRT can effectively target hypoxic volumes within tumors by delivering higher doses of radiation therapy to effectively damage the hypoxic cancer cells whilst modulating the dose intensity within the beam to successfully target the entire tumor.

**It is estimated that as many as 50 percent of radiation therapy patients would benefit from IMRT**

It is estimated that as many as 50 percent of radiation therapy patients would benefit from IMRT. The first reports on the clinical benefits of IMRT are currently being published. A recent randomized Phase III trial conducted by Pignol and co-workers on the use of IMRT in breast cancer demonstrated a highly significant decrease in toxicity to normal breast tissue.\(^\text{10}\) Long-term follow-up studies have also shown that the use of IMRT has resulted in the reduction of severe rectal toxicity in the treatment of prostate cancer.\(^\text{11}\) Currently in the US, IGRT + IMRT is the treatment of choice for treating cancers of the head and neck and prostate, often involving sophisticated treatment sequences of multiple fields, and using more than 100 multileaf collimator transitions between segments.

The radiation therapy treatment approaches discussed so far make use of individual beams of radiation varying in shape and intensity. A new technology known as volumetric modulated arc therapy (VMAT) (see summary box, page 6) is a form of IMRT in which the ‘gantry head’ (the point in a linac through which a radiation beam is delivered) rotates up to 360 degrees around the patient, delivering radiation from every angle. Conventional IMRT uses discrete gantry angles, which means the gantry rotation is stopped in-between individual beam deliveries. With VMAT, multiple delivery parameters (beam intensity, position/angle, speed and dose rate) can be changed while the beam is on, significantly reducing treatment time. It enables multiple arcs of rotation and multiple beam angles, resulting in excellent dose distribution. Through optimum dose distribution, treatment margins are reduced, enabling higher doses to be delivered in a single treatment session and fewer fractions delivered in the course of a patient’s treatment (a process known as hypofractionation). In combination with IGRT, VMAT offers reduced treatment time, highly conformal dose distribution, less opportunity for patient movement, and increased patient comfort. Compared to conventional IMRT, VMAT treatment takes about one-third of the time and at least 50 percent of cancer patients treated with this technique can benefit. In some situations, radiation scatter from the gantry head to whole body is reduced, which may reduce the incidence of secondary cancers. The rapid nature of VMAT may also help to further reduce the possibility of intrafractional changes in the position and size of the tumor.

The above state-of-the-art systems have created their own challenges in treatment planning and patient workflow management — not of the individual patient but planning across a number of patients and a number of treatment sessions. This has accelerated the need for electronic medical records
(EMR) and their integration to image-guided treatment management. Centralized integrated systems are required that enable the distribution of patient data, treatment plans etc, between departments, hospitals (e.g. for a second opinion) and even countries, ensuring safer treatment, and reducing the opportunity for human error and lost information. The ability to circulate plans to treatment centers enables treatment closer to their patients’ homes and avoids the need to travel to major centers, ultimately improving patient quality of life. A revolution is occurring in the ability to view digitally acquired data rapidly between hospitals, making possible remote planning of radiation oncology and Gamma Knife® treatment at centers of excellence. Clearly, in such a progressive and flexible treatment environment, having a reliable but open system, that integrates and works across multiple centers is essential, and is fast becoming the gold standard approach.

More than 50,000 patients every year are benefiting from safe and effective treatment with Gamma Knife® surgery

Advances in imaging technology have also propelled Gamma Knife® surgery into the 21st century. The Leksell Gamma Knife® system in its current form is an immensely precise and effective tool for the treatment of brain tumors with sub-millimeter accuracy. The Leksell Gamma Knife® is a remarkably robust technology with almost no downtime. Due to the accuracy and reliability of the Leksell Gamma Knife®, it is considered the highest standard in head and neck radiosurgery and it has helped secure Elekta as a leading pioneer in the field of radiosurgery.

More than 50,000 patients every year are benefiting from safe and effective treatment with Gamma Knife® surgery. The fourth generation incarnation of the Leksell Gamma Knife® technology, Leksell Gamma Knife® Perfexion™, was developed via a close collaboration between experienced users and industry. A group of users across the fields of neurosurgery, radiation oncology and medical physics were asked: “if you could sit down with our engineers and design the next technology you need, based on your experience, what would you end up designing?” The Perfexion™ model was the product of this unique partnership. This state-of-the art device represents a leap forward in dose distribution, using a patented collimator design which allows extremely accurate sculpting of delivered dose distribution to match the tumor volume.

Redefining the future

The current advancements in the fields of radiation therapy and radiosurgery would once have been consigned to the realms of science fiction. Whereas historical advances in imaging and computer technology have been driven by military innovations, current and future developments are now coming from the computer gaming industries. So what does the future look like in this rapidly evolving area of medical science?

In the immediate term, there is a need for increasing application of radiation therapy and radiosurgery to cancers both of the brain and the rest of the body. This requirement is supported by the fact that in the US alone there are 400,000 new cancer diagnoses per year. As the population ages, the proportion of patients who are candidates for invasive surgery will decrease, so the role of radiosurgery and radiotherapy will increase, both for palliative and curative treatments.

It is apparent that radiation therapy devices capable of delivering very high doses will become increasingly important in treating cancer and a range of other disorders. Leksell Gamma Knife® is already used to treat vascular malformations in the brain, and selected pain and movement disorders.

Summary

• The latest incarnation of the Leksell Gamma Knife® technology, Leksell Gamma Knife® Perfexion™, allows delivery of a single, highlyshaped dose to treat intracranial tumor volumes as well as skull base and selected head and neck cancers
Radiation therapy will also be increasingly used in the current cancer treatment strategy involving drug, targeted drug and chemotherapeutic approaches. The US will lead the way here, due to the existence of relevant reimbursement systems. In Europe this approach is being adopted based on clinical evidence. Underpinning these advancements in radiation therapy, Elekta will continue to refine its 3D volume imaging technology, resulting in unparalleled resolution and contrast, ultimately improving patient outcomes.

**Key trends in the future of radiation therapy/radiosurgery**

- The application of radiation therapy and radiosurgery to cancer treatment will increase
- As accuracy increases, the dose delivered to the tumor volume can increase and the number of treatment sessions necessary may decrease
- Patient management and treatment will be fully digital
- Parallel computing will allow adaptation of the treatment plan prior to each treatment
- Radiation therapy in combination with drug treatments and surgery will help to cure more cancers

Existing inaccuracies in treatment delivery which result from changes in patient position, and tumor size, shape and location after the planning stage are becoming a thing of the past. A new revolution in IGRT known as ‘adaptive’ radiation therapy is allowing the adaptation of a patient’s treatment to physical changes in the tumor and their body. This technique is based on acquisition of imaging data during individual treatment sessions. This enables corrections in beam placement to be made prior to the patient being treated, increasing accuracy and therefore, efficacy and safety further still. Integrated parallel computing systems controlling adaptive therapies will be able to generate sub-second treatment planning, allowing even greater accuracy.

To accommodate this explosion of patient data, major advances will also be made in patient workflow management, resulting in an integrated, filmless, paperless, EMR system.

Looking further ahead, in the next ten to 15 years, we may see advances in labeling tumor-specific molecules to render them more visible to imaging techniques, facilitating even more precise delivery of radiation, and even more specific radiation sensitizers that target specific tumor cells. We will also see earlier detection of secondary metastases as imaging techniques become more refined.

Significant changes will occur in the current thinking on radiobiology. For example, treatment experiences from the brain will be applied to the rest of the body, specifically that when the radiation can be delivered precisely, there is less need for multiple treatment sessions (25 – 30 sessions will be reduced to 5 – 7). Such hypofractionation or single session radiation therapy will become a standard method of care. Knowledge of molecular mechanisms and immune reactions following radiation exposure is increasing, leading to a whole new field of combination approaches termed ‘radioimmunotherapy’. This is an evolving field and has great potential.

It is not difficult to envision the advances that will allow oncologists to remove every cancer cell in a tumor with radiation therapy plus targeted drugs to bring about the holy grail of cancer treatment — a complete cure

Looking further ahead, radiation therapy will be used to assist gene therapy and drug delivery. It is not difficult to envision the advances that will allow oncologists to remove every cancer cell in a tumor with radiation therapy plus targeted drugs to bring about the holy grail of cancer treatment — a complete cure.
Summary

Despite improvements in screening and other preventative measures, worldwide cancer is a major killer, second only to cardiovascular disease. The tools in the global struggle against cancer are surgery, chemotherapy, and radiation therapy. Significant advances have been made in these treatment approaches, but radiation therapy and radiosurgery, in combination with a pharmaceutical approach may offer the greatest potential for longer and improved quality of life, and a cure.

Since radiation was first used for treating cancer at the beginning of the 20th century, several key innovations, underpinned by digitization, with ever more powerful computers, have led to the development of the safe, effective and immensely precise tools the radiation oncologist and neurosurgeon now has at his/her disposal. The evolution from external estimation of tumor size and shape to direct visualization with X-rays heralded the dawn of IGRT. Now, through progression from CT to 3D volumetric imaging, highly accurate images describing the exact location of the tumor prior to treatment has enabled precise delivery of high doses, sparing the surrounding healthy tissues. An estimated 25 – 35 percent of radiation therapy patients are benefiting from IGRT. With implementation of powerful imaging technology alongside individual treatment fractions, IGRT will facilitate adaptation of the radiation treatment to changes in tumor shape, location and size as treatment progresses. Leksell Gamma Knife®, the radiosurgical treatment of choice for intracranial lesions delivers immensely accurate radiation beams. Advances in imaging and beam shaping with Gamma Knife® has yielded a truly revolutionary tool, which is now setting standards for stereotactic treatment of tumors in the head and neck. The application of advanced imaging techniques has now led to the ability, through the use of multileaf collimators, to shape the geometry and intensity of the radiation beam, which when delivered from multiple angles, can apply the radiation dose with exquisite precision, even to tumors that intimately surround vulnerable structures such as the spine. This technology, IMRT, is able to offer improved treatment to ~50 percent of patients, with reduced irradiation of surrounding healthy tissues. Finally, the development of VMAT with 3D volume imaging uses fan-shaped beams of radiation to continuously irradiate tumors through 360 degrees. Importantly, the ability to continually shape and modulate beam intensity yields unsurpassed speed, precision and patient comfort. VMAT has improved treatment times by at least 60 percent and gives hope to around 50 percent of patients.

The devastation felt by patients and families who hear the word ‘Cancer’ is undeniable, and thoughts immediately turn to “how long do I have left?” Now, with the advent of advanced radiation therapy and radiosurgery technologies, which continue to evolve through effective collaboration with clinical centers, combined with new pharmaceutical and chemotherapy approaches, it may not be long before the oncologist is able to tell the patient: “you are cured.”

References
