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Review Article

MR-Guided Radiation Therapy: Clinical Applications & Experiences

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Abstract

Magnetic Resonance (guided) Radiotherapy (MRgRT) is considered a suitable and versatile imaging modality that enhances direct visualization for tumors that surround the wounds among other organs at risk. MRgRT has marked the beginning of a new era, with its ability to provide real-time imaging that tracks and characterizes each anatomical motion. Initially, the technology was challenging, with the next-generation hybrid MR systems still having limited applicability to clinical practice. Adaptive radiotherapy is also an adequate procedure, given the monitoring variations targeting the neighboring structures to enhance uniformity of the treatment procedures. This is sufficient since a single plan may be inaccurate in exploring the wound's exposure. MRI is also adequate as it provides soft tissue superior in image contrasts as compared to the standard X-ray technologies without exposure to radiation.

Keywords: Magnetic resonance imaging; Radiation therapy; Tumors; Wounds

Introduction

Sophisticated radiation techniques, including IMRT (Intensity-Modulated Radiation Therapy), VMAT (Volumetric Modulated Arc Therapy), and SBRT (Stereotactic Body Radiation Therapy), pursue higher goals of delivering the right doses to tumors to heal appropriately [1]. Radiation provides high doses of therapy to cancer, whereas sparingly to the surrounding organs and tissues at risk [2]. Image-guided radiotherapy techniques using CBCT (Cone Beam Computed Tomography) are considered very useful. However, they are limited due to soft tissue contrasts, hence becoming challenging to distinguish the healthy tissues from those with tumors [3,4]. This case, they may consequently lead to an overdose given the uncertainties in the gross tumor volume, dose delivery, target coverage, and delineation [5]. Since the introduction of the technology, (MRI)Magnetic Resonance Imaging has been used before multiple treatment sessions using external radiotherapy beams for planning targeted volume, improving organs at risk, margin reduction, hypo-fractionation, and dose escalation [6]. Over the past decade, MRI technologies have rapidly grown, with Magnetic Resonance Imaging (MRI) diagnostic scanners being held very reliable for improving organs at risk delineation and tumor healing [7]. Magnetic Resonance Imaging (MRI) is used to target high brain tumors, with Fluid-attenuated inversion recoverydelineation fusing with CT for planning RT [8].

Modern external beam radiotherapy: current and future practices

From the research strategy, 21 cases were assessed, with all predefined instances included. Most of the patients' participants in this study showed a definite overall improvement in the next year (Table 1).

No of Studies	Author Name	Year of Publication	Country Origin	Inference
1	Fisher, et al. [9]	2017	United States	MR-IGRT provides a high volume of radiation unique in treating diverse malignancies.
1	Slotman [1]	2019	United States	Technical progress in radiotherapy over the decades has resulted in complexity and preciseness in target coverage while viewing images.
1	Corradini [4]	2019	Mountain View – United States	Evolving rules of radiotherapy with clinical experience was considered useful in the implementation of MRgRT.
1	Giuditta, et al. [10]	2019	Europe	MRgRT is regarded as an essential and promising technology.
1	Raaymakers [11]	2019	Netherlands	Hybrid MRI radiotherapy is effective in targeting the accuracy of images given the accuracy of soft tissue contrasts.

Table 1: The various types of MR radiation therapy and its precise imaging delivery in the treatment of tumor regression.

Discussion

Magnetic resonance image guidance integrated: A cutting-edge technology in tumor treatment

Over the past five years, more patients continue to be treated using the external (RT) beam [12]. Since the implementation of (MR-IGRT) Magnetic Resonance Image Guidance Radiotherapy, the overall

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volume of patients continues to visit the MR-IGRT department, with more integration and accuracy of the nursing professional guaranteeing perfect workflow [5]. Low-field (MRI) Magnetic Resonance Imaging has been considered to have accurate and ideal visualization compared to onboard imaging, including Cone Beam Computed Tomography (CBCT) [13]. Innovations in technology have been the cutting edge for MRI guided radiation therapy, given its positive effects in healing CNS tumors, including pancreatic tumors, Glioblastoma, lung cancer, and ovarian tumor [14]. This has been a new technology providing radiation oncologists with a real-time view of the tumors that cause disease [15].

The technology updated radiation beam target the tumors with high precision, ensuring high monitoring capacity and capabilities [16]. The high-strength MRI machines with real-time images blasted with radiation beams from the accelerator [17]. Linear accelerators have been used over the past few years to guarantee higher precision during tumor treatment [18]. Powerful technologies monitor and track the radiation responses of the patient, ensuring that the tumors are treated appropriately [19]. Over the past few years, individuals with colon cancer have also significantly benefited due to the use of MR Guided Radiation Therapy.

MRI hasalso been useful in guaranteeing perfect and exact tumor location [14]. This movement has been painful to trace over the years during normal breathing, hence marking an extensive inventory in radiotherapy [20]. Significant improvements in the past decade have guaranteed improved delivery systems, with soft tissue tumors being monitored from one treatment session to the next [21]. More innovative approaches have sought to use real-time images, with the specific outcome being a game-changer in the healthcare industry [6].

Assessment of radiation-induced cognitive dysfunction

Millions of patients in the United States are affected by tumors, with the majority of whom undergo induced brain injury surviving long enough [12]. Clinical insights support radiation-induced cognitive dysfunction with a reduction in hippocampal-dependent and hippocampal neurogenesis. It is unfortunate that in the 1970s, scientists considered the brain to be radioresistant, with the central nervous system occurring after more than 30 white and grey matter necrosis after doses above 60 Gy [22].

In the 1980s and 90s, radiation-induced brain injury was identified to cause demyelination, abnormalities, and matter necrosis evident six months after radiation [2]. Unfortunately, late induced brain injury radiations were irreversible and progressive [8]. Consequently, efforts that investigate radiation brain injury focus on the consequences resulting in brain irradiation [12]. Most of these radiation-induced impairments occurring on 50-90 % of the patients who undergo radiation therapy survive more than six months due to improved systematic treatments and radiation therapy techniques [6].

Technical considerations in hybrid mr-radiotherapy systems

The majority of the CNS tumors, including meningioma, lymphoma, craniopharyngioma, and glioblastoma, are most effectively treated using MRI radiotherapy given its ability to provide gold-standard and real-time imaging providing professionals on the actual locating of the tumor for diagnosis process [9]. It is considered one of the highly specialized adaptation to view brain tumors, hence providing appropriate knowledge for optimizing RT outcomes, with higher levels of successful targets [6].

Patients and doctors are expected to benefit from the process, given the accuracy and effectiveness of MR therapy in the provision of care and detection of tumors in comparison to other traditional options [15]. MRI therapy provides accurate and real-time imaging techniques useful in delivering that guarantee treatment of the disease at hand.

Hybrid MR-radiotherapy is considered as one of the gold-standard techniques in radiotherapy, with its ability to treat other multiple cancers and tumors [21]. Its invention marked the beginning of a new era, with its suitable and versatile imaging modality directly influencing the visualization of tumors surrounding organs at risk [12]. MRgRT has also proved effective in providing real-time imaging and tumor occurrences that guarantees to track of the anatomical motions. The majority of the tumors that are adequately addressed include CNS lymphoma, Meningioma, Glioblastoma, and pharyngioma [18]. MR-radiotherapy is also considered one of the groundbreaking technologies given its capabilities in improving patient care, and providing patient-oriented planning, individualized treatment approaches, guaranteeing success to patients [13].

Hybrid MR-Radiation is considered to be the most beneficial technologies in the current decade as it both benefits patients, doctors, surgeons, among other healthcare professionals compared to other traditional methods of treatment [18]. To doctors, MRgRT offers suitable and versatile imaging allowing high-quality visualization of tumors surrounding tissue anatomies. To the patient, this guarantees faster and better treatments [10].

Technical considerations in hybrid mr-radiotherapy systems

One of the significant benefits of the MR Radiotherapy system is that it has multiple benefits to both doctors, healthcare professionals, and patients in treating tumors [18]. It has guaranteed capabilities in providing individualized and patient-oriented treatments, with its ability to allowing high visualization images to identify the exact locations of tumors for effective treatment. MR imaging soft tissue has allowed doctors to be in a position to target the organs at risk [16].

Continuous improvements in the treatment process have guaranteed effective delivery of doses t the tumor and surrounding organs and tissues at higher risks [23]. This has enhanced faster treatment of tumors, with their accurate location proving effective for the location of tissues and tumors needing repair [15]. Healthcare professionals, including surgeons, are dedicated to improving outcomes by inducing MRI systems to treat multiple brain tumors with moderate fractional schemes and a single isocenter [8].

The majority of tumors affecting CNS systems are best treated using RT for the success of both the patient's health and the professional doctor [5]. Metastases including brain tumors such as oligodendroglia, astrocytoma, glioblastomas, meningioma, vestibular schwannomas, pituitary adenomas, among others requiring MRI given its effectiveness in saving costs and time used during the treatment procedures [20]. The imaging technique is considered as one of the old standards MRI, hence guaranteeing quality assessment and treatment processes [18].

In summary, MRgRT has always proved useful, given its ability to provide an individualized and patient-centered approach in adaptation to the intracranial treatment processes [6]. Doctors have preferred the method given its ability to alienate risks and target the affected organs in a quick and fast manner, given the high profile imaging radiotherapy and accuracy during theviewing, planning, localization, and treatment processes [18].

Applications of MRI to central nervous system indication and the challenges ahead

During treatment, patients are likely to get negatively affected as they may significantly lose improving organs at risk and weight gave the shrinking of parotid glands [21]. The time scale required for treatment does also not change, hence challenging to utilize online optimization [12]. In other instances, patients encounter multiple motions reducing MRI workflows when adaptation is highly necessary. Some patients also face discomfort, hence the need to guarantee the effectiveness of MR guidance for tumor and cancer patients [24].

Much concerns have also targeted the inconclusive differential data targeting delineation, dose-fractionation, and dissymmetric in Accelerated Partial Breast Irradiation techniques [9]. Again, margins are considered very effective given their ability to improve patient outcomes given higher volume of patient chest wall movements resulting in larger volumes of external beam radiation therapy [7].

Hybrid MR-radiotherapy systems in clinical use

There exist different kinds of radiation therapy, with all dedicated to guaranteeing that they observe and treat tumors and their surrounding organs and tissues at risk [25]. The most common radiation therapies in the current decade include intensity-modulated RT, volumetric modulated arc therapy, and SBRT, with the goal of monitoring, observing, and delivering doses to treat tumors and improving organs at risk [6].

Technological advancements over the past few decades have guarantees higher levels of accuracy, ensuring that the imaging techniques target specific cells and their surrounding regions to enhance complete healing on the affected areas [7]. This also helps in reducing the amount of time and costs spent in the identification and treatment of tumors in the body, hence shrinking the tumors to improve patient outcomes [25].

MRI in management of brain metastasis for radiotherapy

The quality of life of the patient prior and after undergoing radiotherapy treatments have always guaranteed better outcomes [18]. RT has also proved to be very practical and advantageous as compared to chemotherapy, among other traditional methods of radiation treatments. Over the years, the process has proved effective in guaranteeing a great proposition of dead cancer cells within the tumor and improving organs at risk regions [25]. If any, very minimal cancerous cells are left n the body, hence proving its effectiveness as compared to other chemotherapy treatment processes [5].

Doctors and patients benefit significantly from the effectiveness of RT in tumor treatments, given their effectiveness, accuracy, and efficiency in guaranteeing faster and high-quality treatment for patients at risk [6]. Current research hence continues to emphasize the use of RT compared to other chemotherapies, given its effectiveness in curing cancer and tumors in the patient [4].

The unanswered questions

One major limitation of this process is the inability to accurately precise sufficient concentrations of action on-site, whereas keeping the risks of toxicity low [26]. Studies have demonstrated the need t control and limit toxicity exposure of cells through radiations, with practitioners utilizing high-tech and updated MRI tools to guarantee higher chances for survival [27]. The second limitation of the study is that the population used is tiny, hence ineffective in representing the actual population in the community [23]. It is useful to ensure that the right equivalent doses, as instructed by the medical practitioner, are utilized in the therapy and standard of care [11].

Conclusion

Lastly, pre-operative MRgRT has shown delineation given the less inner-observer variations as compared to postoperative procedures. MRI has proved very sensitive to the detection of findings. Patients also receive earlier detection and treatment for successful clinical outcomes. The robust use of MRgRT improvement and safety applications in artificial intelligence have enhanced improved quality of contours, also reducing uncertainties and improving the overall quality of imaging [28]. Other involved healthcare complications, including Glioblastoma and other ulcers, require unique therapeutic strategies changing the way clients receive their treatment [22]. The past decade has also proven to have deficient tumor control, high survival rates, and reduced toxicity occurrences [18]. More accurate imaging tools and gating solutions have been useful in achieving higher authentic images, hence the effective treatment of tumors in the overall [29].

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