

Magnetic and Radioactive Nanoparticles for Improved Theranostics and AI Assisted Radiation Therapy

Gizachew Diga Milki

Abstract

Nanoparticles based therapeutic and theranostics technique is becoming an active area of research in nanomedicine. The sensitivity, biocompatibility, and stability of magnetic and radioactive nanoparticles determine their functionality. This research highlights the impacts of magnetic and radioactive nanoparticles on therapeutic techniques namely, cell therapy, gene therapy, and tissue regeneration. Then, it is intended to brief a principal role of these therapeutic techniques to envisage theranostics medicine and radiation therapy using the nanoparticles. Currently, a therapeutic and theranostics technique based on magnetic and radioactive nanoparticles is becoming an efficient treatment method for cancer and malignant disease. Moreover, the potential role of magnetic and radioactive nanoparticles in combined effect of diagnostics and imaging is seen. Customary, nanoparticles are investigated for magnetic fluid hyperthermia, magnetic resonance imaging, and theranostics. Moreover, they are good candidate of nano based drug delivery, nanocarriers, and nanozymes. The futures of such therapeutic technique have greater commitment on the AI assisted radiation therapy, theranostics, and drugs delivery system. In turn, the significance of theranostics medicine is investigated for the treatment of epidemics such as atherosclerosis, brain cancer, breast cancer, and cardiovascular disease.

Furthermore, ongoing studies reveal that nanoparticle-mediated therapies can be designed with surface modifications to achieve higher selectivity, minimizing systemic toxicity while maximizing therapeutic efficacy. Functionalization with ligands, antibodies, or peptides allows nanoparticles to actively target diseased cells, enhancing precision medicine approaches. Recent advances in multimodal imaging show that nanoparticles can simultaneously provide diagnostic information and therapeutic intervention, offering a real-time monitoring capability. This dual function not only accelerates the decision-making process for clinicians but also improves patient outcomes by enabling adaptive treatments. As research progresses, integration with machine learning and computational models is expected to refine nanoparticle design, optimize dosages, and predict therapeutic responses. Overall, magnetic and radioactive nanoparticles present a transformative pathway toward personalized, efficient, and safer healthcare systems, bridging the gap between conventional medicine and futuristic nanotheranostics.

Keywords: Cardiovascular disease, cancer, drug delivery, magnetic nanoparticles, radioactive nanoparticles, AI, Therapy, theranostics

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INTRODUCTION

Nanoparticles are nanostructure materials that have sizes in the range 1nm – 100nm. They have distinguished biophysical properties which differ from their host counterparts. The properties of nanoparticles such as optical properties can be influenced by size, shape, compositions, heat, external fields, and surface Plasmon resonance. The magnetic and optical properties of nanoparticles can be stimulated through interaction with magnetic

fields and light.

The quest for adequate diagnosis, therapeutic agents, treatment, and drug delivery system at a cellular level enables foundations of nanoparticles. Some of the predominant nanoparticles include magnetic nanoparticles, metal nanoparticles, semiconductor nanoparticles, radioactive nanoparticles, and lipid nanoparticles. These nanoparticles differ in molecular weights, size, crystal structures, reactivity, biocompatibility, and stimuli to which they respond.

Nanoparticles reinforced with carbon and polymers exhibits relatively high toughness, high young's Modules, and exhibit desirable properties. Other nanoparticles such as $Zn_xFe_{2-x}O_3$ nanoparticles are recognized for nanomedicine due to their varied properties. Although $Zn_xFe_{2-x}O_3$ nanoparticles does not exhibit radioactivity, they can be bombarded with energetic protons to produce radiation for radiation therapy. These nanoparticles are direct narrow band gap semiconductor. They are highly bio degradable, biocompatible, and stable nanoparticles. Although these nanoparticles are very small entity, they are recognized for their biomedical applications. Farnaz Assa et al. 2016 [1] demonstrates that magnetic iron oxides have potential in medical nanobiotechnology as magnetic resonance imaging, biomarker, tissue repair, and immunoassay, detoxification of biological fluids, drug delivery, hyperthermia, and cell therapy. Geppert M and Himly M, 2021 [2] had proven that iron oxide nanoparticles has been used for cancer therapy mediated by hyperthermia, drug delivery, and Iron replacement.

Iron oxide nanoparticles and TM doped Iron oxide nanoparticles are a good candidate in gene therapy, magnetic fluid hyperthermia, and magnetic resonance imaging. Gene therapy is a laboratory test and analysis for cancer, cardiovascular, and autoimmune disease. As Alphandéry, Edouard., 2020 [3] revealed, Iron oxide nanoparticles can improve gene therapy by carrying specific nucleic acid. Moreover, GG De La Cruz et al. 2017 [4] presented that nanomaterials such as SWCNT, DWCNT, Fe_2O_3 , TiO_2 , SiO_2 , and ZnO nanoparticles are used in theranostics, since they do not generate activation energy. S. M. Hosseini et al. 2023 [5] revealed, theranostics nanoparticles can adhere limitations in cancer therapy, drug resistance, low specify to desired tissue, tissue damage, and reduce toxicity.

C. M. Niemeyer and C. A. Mirkin et al. 2004 [6] revealed that metal/semiconductor nanoparticles are used widely in nanobiotechnology as bio labeling, histochemical applications, signal enhancement, and nanocarriers of genetic information. As Kosha J. Metha et al. 2023 [7] revealed, covalently bonded iron oxide with DNA improves MSCs. $Zn_xFe_{2-x}O_3$ nanoparticles enhances cardiovascular tissue regeneration and tissue engineering. Friedrich, R. P et al. 2021 [8] had revealed that IO NPs are widely used in advanced cardiovascular research and experimental therapies, by enabling multimodal imaging and diagnosis of diseases.

Advance in the biomedical application of nanomaterials leads to harnessing, Nanocellulose, metal frame works, and halloysites nano tube. Nanocellulose such as cellulose nanocrystals are enriched with hydroxyl group that enables surface functionalization with ligand. They are performing both imaging and therapeutic activity. Nanocellulose are versatile materials in immunotherapy and enhance theranostics medicine. Metal frame works can form 3D structures for sensing and imaging. Halloysites nanotube (HNTs) such as aluminosilicate can be used in theranostics. They can be used in both diagnosis and therapeutic agent.

Human blood contains Hemoglobin bearing both Fe & O which services as an electron donor and acceptor. Magnetic nanoparticles can bind to hemi of hemoglobin. The interaction of magnetic nanoparticles such as superparamagnetic iron oxide with hemoglobin results in the formation of protein corona. The covalent binding between hemoglobin (hemi) and superparamagnetic iron oxide leads to corona discharge. This phenomenon can also change the surface effects where ultra violet radiation is seen.

Radioactive nanoparticles can interact with hemoglobin via binding, encapsulation, and overlapping. This phenomenon can alter both the structure and functions of hemoglobin. This structural change may lead to either enhanced functionality or may cause toxicity. Nanoparticles that bind to hemoglobin can change the oxygen carrying capacity. This phenomenon can lead to metabolic disorder. It can also produce dynamics of protein structure which eventually lead to toxicity.

Magnetic nanoparticles are good mislabeling materials. They are considered as bio markers for many diseases such as cancers, cardiac disease, and diabetes. Wu, S. et al. 2020 [9] noted that radioactive polymeric NPs represent a promising prospect in the treatment and diagnostics of cardiovascular diseases. As Uinarni, H 2024 [10] noted, nanoparticles-mediated radiopharmaceuticals integrates imaging and therapeutic modalities into a single nanoscale platform to address these challenges and new insights. As F Sabir 2021 [11] stated, nanoparticles such as AgNPs, AuNPs, graphene oxide, Co_3O_4 , carbon quantum dots, and Fe_3O_4 NPs can improve the ability of chemical biomarker for CVDs diagnosis. As A. G. Cattaneo et al. 2010 [12] revealed, radioactive and magnetic NPs are more effective for theranostics applications (Table 1).

Table 1. Primary nanoparticles and their properties

S.N.	Nanoparticles	Properties of nanoparticles
1	Carbon nanoparticles	<ul style="list-style-type: none"> • Are made by grinding pure carbon. • Have high biocompatibility, stability, toughness, fluorescent, and catenation • It also exhibits a good electrical and thermal conductivity.
2	Composite Nanoparticles	<ul style="list-style-type: none"> • Nanoparticles and composites exhibit high mechanical strength, high modulus, low density, high fatigue resistance, and high surface area to volume ratio. • Nanoparticles exhibits super Paramagnetism and good optical properties
3	DNA Nanoparticles	<ul style="list-style-type: none"> • DNA and RNA are negatively charged molecules, hence can be attracted toward the positive charge of Fe_2O_3 nanoparticles at the double layer. • Has an ability to absorb UV light around 260 nm.
4	Fluorescent Nanoparticles	<ul style="list-style-type: none"> • The cellular response of NPs is greatly impacted by particle size, surface morphology, dose, and concentration. • Have ability to emit light in wide range of electromagnetic spectrum. • Examples include: diamond, CQDs, rubies, calcites, and amber
5	Lipid nanoparticles	<ul style="list-style-type: none"> • Lipid nanoparticles are building blocks of glycerol and fatty acid • exhibits good biocompatibility, biodegradability, non-immunogenicity, high drug loading capacity, better stability, and controlled drug release • lipids semiconductors at normal conditions • Lipids nanoparticles exhibit many important optical properties such as light absorption, fluorescence, refraction, and scattering. • Lipids are insoluble in water and act as insulators • Lipids can help to create structures such as liposome which used to encapsulate magnetic nanoparticles.
6	Metal nanoparticles	<ul style="list-style-type: none"> • Metal nanoparticles can have either cylindrical or spherical shape or exhibit spherical symmetry. • Metal nanoparticles have high surface area to volume ratio, high pore size, and are stable. • Metal nanoparticles have high energy density, strong catalytic property, high ignition probability, low sintering temperature, and exhibits super plasticity. • Metal nanoparticles exhibit surface absorption, scattering, extinction, Plasmon excitations, and surface Plasmon resonance (SPR)
7	Metal Organic Frameworks	<ul style="list-style-type: none"> • MOFs are porous and have various crystalline structures ranging from 1D chain, 2D sheets, and 3D extended network. • MOFs can be designed by combining precursors. • The precursor for MOF are thus, metal ions or clusters and organic linker • MOFs are biocompatible, have high strain, have high surface area to volume ratio, and tunable pore sizes which are suitable for various applications.

8	Magnetic nanoparticles	<ul style="list-style-type: none"> • Magnetic nanoparticles exhibits distinguished electrical and optical properties that arise from quantum size effect, quantum confinement, and surface Plasmon resonance. • Magnetic nanoparticles coated ligand, antibodies, scaffolds, or ceramic nanoparticles can be targeted to T-cells, tissues, and lymph system. • These phenomenon leads to different cellular and circular effect such as fluctuations in ionic level such as calcium, magnetism, zinc, sulfur etc. and apoptosis of cell.
9	Polymer Nanoparticles	<ul style="list-style-type: none"> • Magnetic Polymer nanoparticles such as Chitosan are biodegradable, biocompatible, and bioreactive • Polymer nanoparticles exhibit good light absorption capacity, reflection, luminescence and magnetic Dichroism.
10	Semiconductor Nanoparticles	<ul style="list-style-type: none"> • Have varied band gap ranging from narrow band gap to wide band gap. • Their physical properties can be altered by rheological condition such as electric and magnetic Fields, heat, and light • Mostly, binary Semiconductor nanoparticles are preferred in medical applications • Examples of such semiconductors include CdSe, Fe₂O₃, SiO₂, SnO₂, TiO₂, ZnO, ZnSe etc. • These nanoparticles are preferred nanoparticles in imaging, therapeutics, and drug delivery.
11	Radioactive nanoparticles	<ul style="list-style-type: none"> • Most of radioactive nanoparticles have high density, unstable nuclei, and generate high energy. • Most radioactive nanoparticles are not flammable by the virtue of its radioactivity but can pose fire. • They also cannot explode due to different infrared radiations and varied wave length but can explode up on heating.

The table above demonstrates that nanoparticles exhibits distinguished physical properties which are tunable for biomedical applications. As Holman nova, D. et al. 2021 [13] clarified, carbon nanoparticles are used in biomedical imaging and fluorescent targeting. Metal nanoparticles including Au can absorb light which induce heat for Plasmonic therapy. Moreover, radioactive nanoparticles exhibit optical properties such as fluorescence, photoluminescence, and surface Plasmon resonance. Shende, P., & Gandhi, S. 2021 [14] revealed, combination of radiopharmaceuticals with chemotherapeutics and antibodies (peptides) results in theranostics system. Thus, leveraging the mechanical, thermal, electrical, magnetic, and optical properties make them an active research area in nanomedicine, particularly therapeutics, and nano theranostics. In this research, the significance of magnetic and radioactive nanoparticles in cell therapy, Gene therapy, and theranostics technique is presented in detail.

METHODS

Green Synthesis Methods

Different methods can be used to synthesize magnetic nanoparticles including Zn_xFe_{2-x}O₃ nanoparticles. Most importantly, Co precipitation methods, hydrothermal method, Solvothermal method, sol gel method, sonochemical method, solid state reaction method, and biological or Green chemistry method are widely used. As Parmod Kumar et al. 2019 [15], Zn doped Fe₂O₃ nanoparticles can be prepared through a simple approach (sol–gel reaction method) without any organic surfactant. Due to its environmental friendly, cost effectiveness, accessibility at any place and time, Green chemistry method is the choice of this research. Superparamagnetic nanoparticles such as Zn_xFe_{2-x}O₃ nanoparticles can be synthesized by biological method or green synthesis method. This method involves utilization of natural resources including green plants, microorganism and domestic waste including waste water and fruit peels. Moreover, magnetic nanoparticles can be synthesized from magnetotactic bacteria. Naturally, magnetotactic bacteria produce magnetic nanoparticles which are referred to as magnetosomes. Magnetosomes are nanosized solid crystals which are the need of biomedicine, magnetic resonance, and magnetic fluid hyperthermia. Zn_xFe_{2-x}O₃ nanoparticles synthesized in this way are easily biodegradable, biocompatible, ecofriendly, economical and have high medical value.

Although these methods are efficient methods of synthesizing magnetic nanoparticles, they cannot be used to directly synthesize radioactive nanoparticles. Radioactive nanoparticles can be synthesized in two ways; 1) direct irradiation of solution with radioisotope by ionizing radiation and 2) radiolysis method which involves continuous flow system in the mill fluidic reactor.

Characterization Methods

There are a variety of instruments used for synthesis and characterization of magnetic nanoparticles. However, UV-VIS spectrophotometer is used for monitoring the chemical reaction, confirming particle formation, and characterizing its absorption band. In addition, UV-VIS spectrophotometer can provide detailed information about shape, size, and composition of magnetic nanoparticles.

There are many other instruments used to synthesize and characterize magnetic nanoparticles. Importantly, FTIR spectroscopy, X-ray diffractions (XRD), energy dispersive x-ray spectroscopy (EDX), Scanning electron microscope (SEM), High resolution transmission electron microscope (HRTEM), atomic force microscope, vector network analyzer (VNA), and vibrating sample magnetometer (VSM) are significantly used. Moreover, Zeiss microscope used in conjunction with analytic techniques such as EDX and VSM are used to characterize composition, crystal morphology, and magnetic properties of magnetic nanoparticles.

Nanoparticles can be characterized by different instruments. In the simplest way, they can be characterized by scanning electron microscope, atomic force microscope, energy dispersive x-ray spectroscopy. These techniques are used for characterizing the crystal structures, morphology, and distributions of nanoparticles. Magnetic resonance imaging technique is preferred for characterizing the magnetic nanoparticles. However, positron emission tomography is required for radioactive nanoparticles/radionuclide. Since they undergo random motions, their motion can be characterized by dynamic light scattering spectroscopy. This instrument can be used to estimate mean free path and size of nanoparticles by measuring their diameter.

Although these characterization tools can be applicable to radioactive nanoparticles, the effective method is the use of gamma spectroscopy. This method can help to identify the specific radioactive isotopes present in the sample. It can also measure its size, shape, spatial distributions, and radioactivity value.

Researches show that a unified software framework had been developed for magnetic particle imaging reconstruction. As Shen et al. 2022 [16] proposed, a high-performance, flexible, and easy-to-use magnetic particle imaging reconstruction framework was developed by using Python programming language.

Designing nanoparticles

On the other hand, theranostics nanoparticles can be designed by combining the imaging and therapeutic agent by means of a flexible platform. This can be done by conjugation, encapsulating magnetic nanoparticles, and loading therapeutic nanoparticles into existing imaging particles. Particularly, loading micelle or iron oxide nanoparticles into the heme of hemoglobin or surface engineering with polyether such as polyethylene glycol can improve theranostics procedures.

Radioactive nanoparticles can be designed by creating a nano platform that can perform both imaging and treatment. In this procedure, the therapeutic agent is combined with radionuclide while the targeted magnetic nanoparticles must be combined with ligand. In this circumstance, superparamagnetic iron oxide (SPIO) nanoparticles can be combined with ligand to improve the surface effects, biocompatibility, and dispersion. Due to its varied biophysical properties, SPIO nanoparticles can be combined with ligand such as CN^- , ethylenediamine (en), H_2O , and NH_3 etc. for effective theranostics

applications.

DISCUSSIONS

Different methods have been developed for treating cancer. The most common methods are; Physiotherapy, chemotherapy, radiotherapy, and fluid hyperthermia. Currently, gene editing, CRISPR Cas - 9, Post Genomics, cell therapy, Gene therapy, immunotherapy, and theranostics is emerged as newly effective methods for treatment of cancer and cardiovascular disease. Other involves detection method using nanobased device including biomarkers, biosensors and nanorobots. These devices are inherently used for detecting, monitoring, and managing magnetic nanoparticles for enhanced diagnosis, imaging, therapy and theranostics in conjunction with drug delivery. However, attention is given to only three important treatment techniques cell therapy, gene therapy, and theranostics. Here, the impact of magnetic and radioactive nanoparticles in maximizing the potential application of such medical treatments is discussed in detail.

Magnetic nanoparticles such as superparamagnetic $Zn_xFe_{2-x}O_3$ and ZnO have multidisciplinary role in therapeutic and theranostics technique. Customary, these nanoparticles are evaluated for magnetic fluid hyperthermia and magnetic resonance imaging. Moreover, they are good candidate of nano based drug delivery, Nanocarrier, and nanozymes. The future of such therapeutic techniques has greater commitment on the AI assisted therapeutic and drugs delivery system. By integrating IoNTs with the existing medical tools, we can improve the drug delivery for smart health care system.

A notion toward the biomedical application of nanoparticles make it fulcrum of therapeutic and theranostics applications. Moreover, the need for enhanced diagnosis, therapeutic agent and theranostics medicine require nanoengineered nanomaterials. Premature nanomaterials specialized for these applications are carbon nanotube; metal organic frame works (MOF), Nanocellulose, and radioactive nanoparticles. In this section, magnetic and radioactive nanoparticles are discussed for applications in cell therapy, Gene therapy, immunotherapy, and theranostics. Most importantly, their principal role of these nanoparticles is seen for cancer therapy, diagnosis, and imaging of cardiovascular disease.

Cell Therapy

Solid brain cancers and abnormal cells form a mass or lump called a tumor. Solid brain tumor (gliomas) arises from the glial cells which that reinforce neural system in the brain. Traditional treatment methods including surgery and radiotherapy are challenging for treating such kind of tumors. However, the use of magnetic nanoparticles for enhanced cell imaging, magnetic fluid hyperthermia, and drug delivery can minimize the threat. Health systems need to do much more to integrate CGTs into ordinary health care system. The effectiveness of cell therapy is associated with the cell migration, cell engraftment, cell homing, cell proliferation, and differentiation.

Designing magnetic nanoparticles (MNP) involves surface engineering, size optimization, and improving the biocompatibility. Particle with small size has low scattering, exhibits a spatial distribution, have high surface area, and has high penetration power. In cell therapy, magnetic nanoparticles perform cell tracking, cell targeting, cell delivery, and intervene in the therapeutic process by heating tumors etc. Magnetic nanoparticles can interact with magnetic fields which help them in cell guiding, drug delivery system, and etc. As Chen Y & Hou S. 2022 [17] explained, in cell therapy, magnetic nanoparticles interact with external magnetic field to attain cell direction and monitor cell distribution.

Radioactive nanoparticles can be incorporated in cell therapy for the apoptosis of cancerous / or tumor cell. Radioactive nanoparticles also increase the effectiveness of cell and radiation therapy due to their sensitivity. Cell therapy plays significant role in improving radiation therapy. By combining radiation therapy with cell therapy particularly CAR T- cell therapy and stem cell therapy enable better cancer treatment. CAR T cells and cell therapy can also reduce radiation does and toxicity. Consequently,

cell therapy can improve the radiation therapy by minimizing the health risk effects of radiation.

Gene therapy

Gene therapy: the use of genetic material to treat human disease. It is a treatment by transferring the exogenous gene or gene fragment into the target gene of patient. Gene therapy is done to treat tumors by using vectors or nanocarriers that have been derived from virus, proteins, and biopolymers. Example: retrovirus, adenovirus, addino associated virus, and herps virus or using non viral vectors such as Naked DNA, DNA in Liposome, or DNA attached to ligand. As De La Torre et al. 2016 [18] non-viral gene delivery systems have provided novel possibilities of materials for designing carriers with low immunogenicity, low toxicity, and low cost. In regenerative medicine $Zn_xFe_{2-x}O_3$ helps to behave biomarker, cell therapy, gene therapy, and tissue engineering. Other nonorganic - organic double layer such as Fe_2O_3 -DNA exhibits desired bio-physical properties which enable cell therapy, gene therapy, and drug delivery.

There are two approaches to do with gene therapy. These are;

1. Directly killing *the tumor cells*: - *this is done by introducing gene such as tumor necrosis factor, ricin* (pant toxin). Tumor necrosis factors are proteins or cytokines produced by immune system which defend against inflammations or tumor growth. Magnetic nanoparticles must be guided by alternating magnetic fields in order to induce heat. The guided magnetic nanoparticles enhance tumor necrosis leads to tumor cell death and apoptosis. Tumors necroses factors can repair injure and help wound healing.

Moreover, radioactive nanoparticles used in conjunction with radiation can directly target to tumor cell leading to cancerous cell death. Radioactive nanoparticles generate reactive oxidative species (ROS). This reactive oxidative species are allowed to undergo different process including necrosis in order to cause tumor cell death.

2. *Utilizing tumor suppressor gene such as Protein 53, P₅₃, and retinoblastoma susceptibility gene*. Tumor suppressor gene serves as a flexible motor which prevents irregular cellular activities which leads to cancer and tumor growth. Mostly, tumor suppressor genes prevent irregular cell growth, cell divisions, and loss. Magnetic nanoparticles (MNPs) can enhance tumor suppressor cells. As the present work reveals, magnetic nanoparticles enhance suppressor cells by boosting the activity of macrophage. Moreover, magnetic field guided magnetic nanoparticles can directly tuned for gene therapy. However, radioactive nanoparticles do not reinforce tumor suppressor cells instead they are targeted directly to kill cancer cells.

As Porteus MH et al. 2006 [19] verified, Gene therapy strategies employing the use of many viral vectors, such as retroviral vectors, are based on the uncontrolled integration of a therapeutic gene. Radioactive nanoparticles can enhance gene therapy by generating radiation at the tumor site. Moreover, radioactive nanoparticles increase the kinetic energy and drug kinesis hence they reinforce the drug delivery radioactive nanoparticles plays central role in combining gene therapy with radiation. Hence, they improve caner and tumor therapy.

Herranz F, et al. 2011 [20] revealed, gene theranostics, involves diagnosis and treatment by the means of nano bioconjugate. However, vector network /nano carriers are used for binding genetic information with magnetic nanoparticles. A radioactive nanoparticles combines biocompatibility, precisions, and specify of nanoparticles with UV/infrared radiation leading to effective cancer therapy. Besides, some genes such as P₅₃, is used in conjunction with radiation.

Immunotherapy

Immunotherapy is leading cancer treatment techniques that reinforce the growth, repair and recovery of immunity system. It improves the bodies defend system and widely used in connection with surgery, radiotherapy, chemotherapy, and gene therapy. As Canese, R et al. 2021 [21] demonstrated, innovative cancer Immuno therapies become increasingly relevant in the fight against cancer. Immunotherapy help

in theranostics medicine as it improves diagnosis and therapeutic modalities. Immunotherapy transform theranostics medicine as it incorporates theranostics agents such as magnetic nanoparticles. Nanoparticles such as magnetic nanoparticles, metal nanoparticles, carbon nanotube, metal organic frame works, and Nanocellulose are versatile platform for drug delivery, which simultaneously exhibit diagnosis and therapy. It is possible to label for example Nanocellulose for bio imaging as biomarkers, fluorescent dyes, and radioactive isotopes to take sample of drug distribution to perform immunotherapy at the point of care. Moreover, crystalline Nanocellulose can be use as stage for fluorescent imaging, diagnosis, and chemotherapy.

These nanostructures are inevitably used in Immunosensors for inflammation, targeted therapy, and drug delivery system for strokes and brain cancer. In immunotherapy, Radioisotopes can also imping monoclonal antibody with radioactive nanoparticles for optimum delivery of radiation to cancerous cell. Hence, radioisotopes increase the effectiveness of immunotherapy by increasing intensity of radiation to decline cancer cell and targeting capability of antibody. Hence, it can improve theranostics medicine.

Nanoscale devices like nanorobots serve as vehicles for delivery of therapeutic agents, detectors of disease, and help to repair damaged tissue or genetic disorder. AI can help to predict disease progression and patient outcome, by analyzing the sample and characterizing immune cell population. Moreover, AI based immunotherapy reduce trial, error and inspection methods which enables to patients response to stimulus and specific drug. In addition, generative AI can generate patient's data, help to analyze data using AI algorithm, and enable to predict patients' outcome.

While radiation therapy can damage cancer cells, immunotherapy including check point inhibitor enhances immune system. Immune system overcomes the tumor's resistance against therapy by eliminating cancer cells more effectively. Hence, accelerate radiation therapy. It is expected that that combining radiation therapy with immunotherapy will increase the survival rates. As Taylor R. Cushman, 2018 [22] indicates, Combining radiation therapy and immunotherapy has shown promise in clinical trials, recommended for improved survival rates and reduced recurrence in certain cancers. Moreover, Zhang, Z. 2022 [23] had revitalized immunotherapy and radiation therapy (IRT) has made a breakthrough in both preclinical studies clinical trials, answer toxicity question. This combination therefore has profound contribution in surveillance.

Radiation therapy

Medical treatment that uses energetic electromagnetic radiations involves killing or deactivating DNA, RNA or a specific gene of particular disease. Radiation therapy can be performed for the treatment of cancer and tumors by deactivating the DNA or killing cancerous cells. These treatments can cause total destruction of malignant or cease cancer duplications.

Radiation therapy can be used to treat some disease rather than cancer. Particularly, it can be used to treat benign tumors, Graves' ophthalmopathy, trigeminal neuralgia, and to prevent keloid scar and heterotopic bone formation. Particularly, Graves' ophthalmopathy, referred to as thyroid eye disease, is an autoimmune condition affecting the tissues around the eyes. On the other hand, Trigeminal neuralgia is a chronic disorder that impacts the trigeminal nerve, which is responsible for sensation in the face and characterized by electric shock. This kind of pain can be treated by nerve blocks and Gamma Knife radio surgery. Hence, radioactive nanoparticles impact such treatment indirectly via emitting gamma radiations and undergoing radioactive decay process. The heat generated by radioactive nanoparticles can be controlled by selecting the type, shape, size and impact of stimuli such as light, magnetic field. It can also be controlled by applying the closed loop control systems such as solenoid switch can be used to monitor temperature of the targeted tissues. Hence, has significant role in treating cancer and malignant disease via magnetic fluid hyperthermia.

Magnetic nanoparticles (MNPs) reinforce radiation therapy by minimizing the health risk effect of radiations. Magnetic nanoparticles can change the direction of hard radiation that imping on the surface

of cell to slant and reduce damage to cells. Magnetic nanoparticles also induce heat and enhance cancer therapy such as hyperthermia. Although $Zn_xFe_{2-x}O_3$ nanoparticles does not exhibit radioactivity, they can be bombarded with high energy particles such protons and positron to produce radiation. The electromagnetic radiation produced in this war is used for killing cancer cells and enhance for radiation therapy. $Zn_xFe_{2-x}O_3$ bombarded with positron can produce gamma radiation via positron-electron annihilation. These radiations are adapted for damaging DNA of cancerous cell and prevent tumor growth and replications.

Radiotherapy can even kill normal cells and retard normal tissues. Radiation therapy is aimed at killing cancerous cell, controlling growth and duplications of cancer cells managing health risk effect of radiation. AI plays significant role in radiation therapy. AI based device such as nanorobotics are designed to automate physical activities such as mentoring radiation dose, image analysis, facilitating adaptive treatment, and predict patents outcome. It also helps to analysis patients data, simulate and interpret simulated data. As Jiang C. et al. 2024 [24] AI algorithms can elucidates medical imaging data to determine the appropriate dose required for efficient tumor treatment. Overall, AI based radiotherapy transforms radiation therapy by enhancing precision, and bring better patients outcome.

Nano theranostics using magnetic and radioactive nanoparticles

Nanotheranostics is an integration of nanotechnology and theranostics medicine. It is medical procedure that combines nanodiagnosis with therapeutic agents such as nanoparticles. Nanotheranostics is specialized for efficient and rapid therapeutic and diagnosis procedure simultaneously. It enables real time analysis and monitoring of diagnosis, drug distributions, drug kinesis, and drug efficacy. Nanotheranostics is designed for cancer and cardiovascular diseases. It enables imaging and diagnosis of lung cancer, liver cancer, heart cancer, breast cancer, brain cancer, cervical cancer, and womb inflammation harmlessly.

Theranostics nanoparticles can help to visualize and treat disease such as atherosclerosis, myocardial infarction, and cardiovascular disease. These nanoparticles have high sensitivity, biocompatibility, and cell viability. Hence they can be used in diagnosis, imaging, and therapy for ultimate goal of enhanced theranostics. In addition, to increased accuracy and precision, nanotheranostics helps to monitor and manage the effectiveness of the treatment and medical outputs. Actors of such nanoparticles include carbon nanotube, silver nanoparticles, Fe_2O_3 nanoparticles, micelle nanoparticles, metal organic frame works and etc.

Among these structures, Metal-Organic Frameworks (MOFs) serve as scaffolding materials in tissue engineering, wound dressing & healing, bone repair, cell growth and repair. Specifically, in tissue engineering, MOFs can act as biocompatible scaffolds that support cell growth and tissue regeneration. As Senja Barthel et al. 2018 [25] revealed, by changing the metal type or substituting the functional group of organic linker, its biophysical property can be improved systematically. Moreover, metal organic frame works can be used in cancer theranostics, brain disorder, and drug delivery.

Magnetic and radioactive nanoparticles are permissible in therapeutic and theranostics techniques. By leveraging their sensitivity, biocompatibility, and stability MOFs can be engineered for magnetic resonance imaging and nuclear medicine. Both magnetic and radioactive nanoparticles can be characterized by same techniques particularly UV-VIS spectroscopy. This enables us to transform both Magnetic and radioactive nanoparticles into radiation and cancer therapy.

Metal nanoparticles such as Au nanoparticles exhibit localized surface Plasmon resonance (LSPR). This property makes Au nanoparticles suitable in diagnosis, therapeutic procedures, and drug delivery which make it a good theranostics agent. Magnetic nanoparticles can also serve as nanocarriers and enhance signal transfection. Furthermore, functionalized biomolecules enhance the capability of magnetic nanoparticles for targeted drug delivery & reduce the systemic toxicity of drugs. Magnetic

$Zn_xFe_{2-x}O_3$ is more advantageous since it can be easily attracted by magnetic field induced by the infected site. This phenomenon enables nano absorption during targeted drug delivery.

Loaded $Zn_xFe_{2-x}O_3$ would enable both imaging and diagnosis process. Incorporating $Zn_xFe_{2-x}O_3$ nanoparticles for dual mode imaging of cancers enables treating hematomas by introducing the Thymidine Kinase (TK) gene with a cytokine gene into patients by using hepatic artery catheterization & chemical embolisation to delivery viral vector, YW Khan, 1998 [26]. TK are vital materials for apoptosis, cell proliferations, embryonic development and enhance regenerative and theranostics medicine. CGTs should be performed by the IoNTs. The Internet of nanothings (IoT) can significantly improve the quality of cell and gene therapy by enabling monitoring, data generating, and data analyzing. It can also enhance managing drug delivery process and patients health. AI assisted or Photon assessed CGTs become an alternative approach to Photodynamic therapy.

Pyrimidine dimmers (PD) have impact on brain cancer. Pyrimidine dimmers are formed from UV light activated nearby thymine base in DNA. Unpaired pyrimidine dimmers can cause mutations during DNA duplication. Unrepaired DNA results in brain tumors like Glioblastoma. Pyrimidine dimmers can trigger cellular repair including nucleotide excision repair. However, PD has health risk effect and can interfere with DNA duplication and transcription. Magnetic field guided nanoparticles and AI assisted theranostics medicine is a solution for such health problem.

Sri Amrutha et al. 2022 [27] revealed, that Nano theranostics became a potential tool to overcome the critical challenges faced in personalized medicine. As Shakil MS, Hasan MA, Sarker SR. 2019 [28] published, iron oxide nanoparticles have been successfully used as theranostics agents for breast cancer for in vitro and in vivo. Radioactive nanoparticles can be placed directly inside the womb of cancer patient, to decline tumor and treat cervical cancer. As Nicole Jawerth (IAEA), 2024 [29] presented, brachytherapy allows treatment of tumor with high doses of localized radiation. Salbu, B. 2018 [30] identified challenges related to radioactive nanoparticles. In high dose, radio pharmaceuticals leads to cell damage. The cost of licensing for theranostics may also be another challenge. Radioactive nanoparticles can produce radiations which can burn skin, cells, and tissues. The acute effects are responsible for cancer and cardiovascular disease (Figure 1).

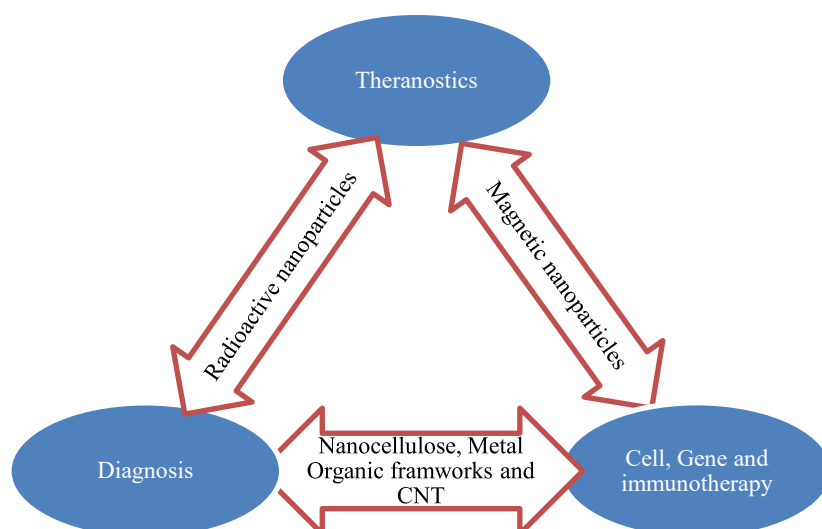


Figure 1. Theranostics Medicine

Radioactive nanoparticles are the demand of diagnostic nuclear imaging techniques such as Positron emission tomography and CT tomography. To perform the therapeutic procedure, radiotracers must be administered to targeted cell and positron emission spectroscopy to perform imaging applications. Radioactive nanoparticles such as thorium pose high density and serves as a good contrast agent in

medical radiography. Thorium-227 is also used in cancer therapy for radiation dose. Although, thorium has good medical applications, there are also responsible for many health risk effects such liver disease, blood clotting, blood cancer, gall bladder cancer. Moreover, radioactive nuclei's such as Co-60 is applicable in external beam radiotherapy (Teletherapy). Hence, controlling, and piecewise study on the health risk effect caused by such radioactive nanoparticles is anticipated.

CONCLUSION

Nanoparticles are driving force in nanomedicine. They are engineered for therapeutic and theranostics applications. Mostly, carbon nanoparticles, composite nanoparticles, DNA nanoparticles, fluorescent nanoparticles, lipid nanoparticles, magnetic nanoparticles, metal nanoparticles, metal organic frameworks, Nanocellulose, polymer nanoparticles, semiconductor nanoparticles, and radioactive nanoparticles are leading theranostics agents. They perform both diagnosis and therapeutic function simultaneously. More importantly, magnetic nanoparticles enables both diagnostics and imaging modalities easier with improved efficacy and contributes greatly for enhance theranostics medicine. Radioactive nanoparticles can be designed for cancer therapy while it is not advised to directly treat cardiovascular disease due to its inflammatory effect. Controlling challenges related to cell therapy, Gene therapy, and immunotherapy can greatly improve Theranostics medicine in order to fully control and treat the epidemics of atherosclerosis, brain cancer, breast cancer, cardiovascular disease, and other infections disease. AI assisted theranostics medicine is a solution to unravel challenges related to monitoring and disease management. Particularly, using AI based devices such as nanobiosensor, Nanorobotics, and IONTs enable detecting, monitoring, and managing glucose level, cancer cells, radiation dose, and treating cancer particularly brain cancer, breast cancer, etc, and cardiovascular disease efficiently.

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Author's declaration

I declare that this work is done by my effort and some terminologies and states which are adapted to this manuscript where properly acknowledged.

Conflict of interest

I declare that there is no conflict of interest.

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