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The Role of CT scan and MRI in Evaluating Bone Marrow Diseases in Children

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Abstract

To maximize the patient's chances of long-term survival and reduce the likelihood of any potential hematologic, skeletal, or neurological problems, a bone marrow evaluation is crucial. For more accurate diagnosis and treatment of non-specific diseases or those with severe symptoms, doctors employ CT and MRI scans. When a child has a disease or condition that could affect their bones or bone marrow, more and more computed tomography (CT) and magnetic resonance imaging (MRI) tests are being used to find, describe, and track bone marrow abnormalities. Studies with the same variables included in the research issue are scarce, according to earlier research. By looking over earlier research on the dependent and independent variables of the study, the researcher used the descriptive approach.

Keywords: *Bone marrow, computed tomography (CT), magnetic resonance imaging (MRI), children, symptoms, bone marrow diseases*

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المخلص

يعد فحص نخاع العظم ضروريًا لزيادة بقاء المريض على قيد الحياة على المدى الطويل وتقليل أي مشاكل دموية وعظمية وعصبية محتملة. يستخدم الأطباء التصوير المقطعي والتصوير بالرنين المغناطيسي للحصول على توصيف ودقة أفضل عند علاج الأمراض غير المحددة أو تلك التي تظهر عليها أعراض عدوانية. زاد استخدام التصوير المقطعي (CT) والتصوير بالرنين المغناطيسي (MRI) لتحديد وتوصيف ورصد آفات نخاع العظم لدى الأطفال الذين يعانون من أمراض وعلل قد تؤثر على العظام أو نخاع العظام. ووفقا للدراسات السابقة هناك نقص في الدراسات التي تناولت نفس المتغيرات الداخلة في موضوع البحث. وقد طبق الباحث المنهج الوصفي من خلال مراجعة الدراسات السابقة المتعلقة بمتغيرات البحث التابعة والمستقلة.

الكلمات المفتاحية: *نخاع العظم، التصوير المقطعي، التصوير بالرنين المغناطيسي، الأطفال، الأعراض، أمراض نخاع العظم*

1. Introduction

A bone marrow examination is essential to increase the patient's long-term survival and minimize any possible hematologic, bone, and neurological issues. The effects of significant bone marrow disorders, including bone and marrow deposits, can be observed using specific radiological techniques. Therefore, depending on the histological subtype, the bone marrow (BM), which is present in 5–15% of Hodgkin lymphomas (HLs) and 20–40% of non-Hodgkin lymphomas (NHLs), is a significant location (Chan, 2016).

When a lymphoma is first discovered, BM status evaluation is crucial since it establishes the stage, prognosis, and necessity of longer chemotherapy or radiation treatments. An essential component of the Ann Arbor lymphoma staging method is the examination of bone marrow. It is commonly carried out using an invasive

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procedure called bone marrow biopsy of the posterior iliac crest (BMB), which only examines a small area at a time (PROYTCHEVA, 2013).

According to Cistaro (2018), the main screening method for tumor-like illnesses and bone tumors is radiography. Physicians use CT and MRI scans for better characterization and accuracy when treating non-specific diseases or those that exhibit aggressive symptoms. These scans can reveal components including cartilage, vascular tissue, fat, fluid, and hemosiderin, which can further widen the scope of the diagnostic examination. An MRI and CT scan can assist by reducing the range of possible diagnoses, even in cases where a particular diagnosis cannot be made.

MRI is a sensitive non-invasive method to assess the composition of the bone marrow. The infantile hematopoietic marrow changes into fatty marrow throughout skeletal maturity. It's critical to understand typical conversion patterns to identify myeloid disorders. Many diseases, such as myelodysplasia, tumor infiltration, myeloid depletion, myelofibrosis, edema, and ischemia, involve changes in bone marrow signaling (Abbas, 2023).

According to previous studies, radiologists' primary responsibility is to use sophisticated imaging tools to determine the quantity and location of bone lesions. Several previous large sample studies have evaluated the DI of MM using MR imaging of the spine or pelvis, which is considered the gold standard technique for measuring DI of the bone marrow. Because CT has a wider field of view (FOV) and is more readily available than whole-body MR imaging, it is used for evaluating bone marrow illness more frequently than regular MR imaging (Abbas, 2023; Elamir, 2020).

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Using glucose metabolism, CT is a whole-body imaging modality that provides functional information about the cells. Metabolically active cells, including cancerous cells, absorb radioactively labeled glucose more readily and turn visible. This technique can be applied to aggressive NHL and Hodgkin lymphomas (HL), among other malignant tumors, to stage and evaluate treatment response (Cistaro, 2018).

Numerous illnesses may be the cause of children's polyostotic bone and bone marrow lesions. The use of computed tomography (CT) and magnetic resonance imaging (MRI) for the identification, characterization, and monitoring of bone marrow lesions in children with illnesses and ailments that may possibly impact the bones or bone marrow has increased. Because red bone marrow is common in children and most lesions show a nonspecific patter of low intensity on T1-W sequences and high intensity on T2-W sequences, the interpretation of the results may be particularly challenging, according to (Hao, 2018; Forshult, 2007)

Red marrow makes up almost the whole osseous skeleton at birth. Yellow marrow is seen in the apophyses and epiphyses of children older than one year. Red marrow patches persist in the axial skeleton and near the proximal metaphysis of long bones as aging advances. Red marrow rests or changed biomechanics may be the cause of stippled patches of aberrant signal found in the short bones of the feet. In contrast to yellow marrow, red marrow shows higher apparent diffusion coefficient values, mild gadolinium enhancement, and larger signal decline on opposed-phase gradient echo sequences (Balasubramanian, 2022).

Children receiving treatment with hematopoietic growth factors (erythropoietin and granulocyte-macrophage colony-stimulating factor) should get

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extra care. Focuses of bone marrow reconversion in these children arise a few weeks after medication initiation, may mimic diffuse marrow involvement mentor metastases on MRI, and correlate temporally with elevations in neutrophil levels. Generally speaking, bone marrow on T1-W sequences in children older than a year old should have a signal strength that is either higher or comparable to that of the surrounding hyaline cartilage or intervertebral discs (Raissaki, 2017).

2. Research Problem

The most sensitive imaging modality to assess the marrow is magnetic resonance imaging (MRI), and abnormalities of the bone marrow (BM) in the spine are common, occasionally unexpected findings (Gupta, 2017). However, novice radiologists may find it challenging to interpret these findings. The risk of death and skeletal-related events (SREs) was consistently higher when bone metastases were present. SREs have been associated with increased morbidity, higher treatment costs, and lower quality of life (Vissers, 2023). According to previous studies, there is a lack of studies with the same variables involved in the research topic. Regarding this, the study seeks to answer the following main question; **“What is the role of CT scan and MRI in Evaluating Bone Marrow Diseases in Children?”**

The main questions are subdivided into the following sub-questions:

1. What is the role of CT in evaluating bone marrow diseases in children?
2. What is the role of MRI in evaluating bone marrow diseases in children?

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3. Research Objectives

The current research sought to investigate the main objective **"The role of CT scan and MRI in Evaluating Bone Marrow Diseases in Children".**

This main objective is subdivided into the following sub-objectives:

- Investigate the role of CT in evaluating bone marrow diseases in children.
- Investigate the role of MRI in evaluating bone marrow diseases in children.

4. Significance

The importance of this study stems from the importance of awareness of the role of both CT and MRI in evaluating bone marrow diseases in children. There are many studies centered on the current research variables as separate parts. Therefore, conducting such a study on this topic is expected to have a great positive impact and importance, which can be summarized as follows:

- This study will be a useful source of information about the role of computed tomography (CT) in evaluating bone marrow diseases in children.
- Referring to previous studies centered on the research topic will be crucial. It can be referred to determine the role of magnetic resonance imaging (MRI) in evaluating bone marrow diseases in children.
- On the other hand, the results of this research may help in preparing awareness sessions about the difference between child bone marrow and adult bone marrow diseases.
- Given the scarcity of previous studies related to the current field of research, this research will represent a good reference for future studies as long as it will

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provide subsequent researchers and scholars interested in the field of the role of CT and MRI in evaluating bone marrow diseases in children with valuable literature, important recommendations and suggestions for their proposed studies.

5. Literature Review

5.1 Bone Marrow (BM)

The core chambers of the axial and long bones contain the bone marrow. It is made up of adipose cells and islands of hematopoietic tissue intermingled in a network of trabecular bone, encircled by vascular sinuses. It represents about 5 percent of all humans (Raissaki, 2017).

According to Marilyn (1996), a hematological component called parenchyma and a circulatory component called stroma make up bone marrow. Hematopoietic stem cells (HSCs) and hematopoietic progenitor cells are found in the parenchyma; they are not found in the bone marrow at random; rather, they are localized toward the endosteum of the bone and more closely around blood vessels. Multipotential non-hematopoietic progenitor cells that can differentiate into a variety of mesenchymal-derived tissues can be found in the bone marrow stroma.

Depending on the histological subtype, bone marrow (BM) is present in 5–15% of Hodgkin lymphomas (HLs) and 20–40% of non-Hodgkin lymphomas (NHLs). BM is a key extent site. In newly diagnosed lymphomas, the evaluation of the bone marrow status is crucial because it establishes the stage, diagnosis, and whether longer-term chemotherapy or radiation therapy may be necessary (Alvaro, 2009).

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A sinusoid is formed by the single layer of endothelium in the bone marrow's microvasculature, and it is radially spread around the central sinus that drains. The barrier that separates the peripheral circulation from the extra lymphoid organ and the bone marrow compartment as a functional entity is provided by the vasculature. Although it lacks the structured T and B cell regions, bone marrow has follicle-like structures mimicking lymph nodes or the spleen, and it exhibits morphological and functional characteristics of a secondary lymphoid organ. In the absence of the thymus, the bone marrow microenvironment offers the right kind of support for T cell development (Brandis, 2022)

According to Chan (2016), lymphocytes make up between 8% and 20% of bone marrow mononuclear cells. Bone marrow lymphocytes are found in lymphoid follicles and are dispersed throughout the stroma and parenchyma. The bone marrow mononuclear populations include plasma cells, which are capable of producing antibodies, in about 1% of cases.

Numerous cell types, such as adipocytes, macrophages, adventitial/barrier cells, blood cells, and their progenitors, make up the hematopoietic tissue. The hematopoietic tissue cells exhibit a specific order inside the tissue rather than being placed randomly. Hematopoiesis requires a microenvironment that can identify and hold onto hematopoietic stem cells as well as supply the elements (such cytokines) needed to promote the growth, maturity, and differentiation of stem cells along committed lineages (PROYTCHEVA, 2013).

According to previous studies, the bone marrow (BM) is the principal location of hematopoiesis and the last blood-forming tissue to mature during ontogenesis and from birth. It is a dynamic organ whose composition is greatly influenced by the

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need for appropriate hemostasis, infection prevention, and oxygenation. Since these needs range greatly between developmental phases, early childhood, and later in life, the composition of BM also varies to satisfy those needs. As such, it is critical to differentiate between findings attributed to normal development and those resulting from various disorders while analyzing a child's BM (Alvaro, 2009; Balasubramanian, 2022; PROYTCHEVA, 2013).

According to Marilyn (1996), at 6–8. 5 weeks of gestation, the hematopoiesis in the bone marrow starts in the long bones. By 16 weeks of gestation, the ultimate organization of the bones is into zones of intense hematopoiesis encircled by areas of fully calcified bone. Both the liver and the bone marrow (BM) are hematopoietic organs concurrently between weeks 11 and 24, but they each support a distinct set of hematopoietic lineages: the fetal liver is primarily where erythropoiesis occurs, while the BM is primarily where granulopoiesis and lymphopoiesis occur. During the second trimester, the total marrow volume increases noticeably, and the hematopoiesis moves from the fetal liver to the bone marrow after the 24th week of gestation.

PROYTCHEVA (2013) asserted that the BM is the primary hematopoietic site from birth forward. Almost no fat and red hematopoietic bone marrow are present in all of the skeleton's cavities at birth. Hematopoiesis occurs in the axial and appendicular skeletons during the first year of life. After that, the hematopoiesis in the long bones gradually decreases until the age of around fifteen. At this age, the proximal portions of the femur, humerus, and axial skeleton are the only areas where active hematopoiesis occurs.

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Vissers (2023) asserted that because the bone marrow replaces fat when hematopoiesis expands in response to an increase in the need for platelet, leukocyte, or erythrocyte production, the BM is a functionally dynamic structure. But in young children, a decrease in the percentage of marrow sinusoids allows for an increase in hematopoiesis, and in cases of severe congenital anemia, the marrow cavities enlarge and cause bone deformities.

The BM is made up of capillary venous sinuses, stromal cells, including osteoblasts, and extracellular matrix. It is situated in between the bone trabeculae and has a very intricate three-dimensional structure. The distinct hematopoietic elements are not randomly distributed; in histologic sections, proliferative cells are found in the vicinity of the bone trabeculae, while differentiated elements are found in the center, intertrabecular areas (Balasubramanian, 2022).

PROYTCHEVA (2013) indicated that the diagnosis of bone marrow in both children and adults is based on the combination of information from multiple diagnostic studies, such as BM aspirate smears, particle clot sections, BM trephine biopsy, peripheral blood count and film evaluation, and the outcomes of cytochemistry, immunophenotypic analysis, cytogenetics, and molecular studies. The most common reasons for a bone marrow examination in children are as follows: after treatment for acute leukemia and detection of minimal residual leukemia; investigation of abnormal blood counts suggestive of BM pathology; initial workup for a child with peripheral cytopenia and suspected primary bone marrow failure or occult malignancy; unexplained organomegaly in children with mass lesions inaccessible for biopsy; to determine for Hodgkin or non-Hodgkin lymphoma, neuroblastoma, or rhabdomyosarcoma.

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Bone marrow failure (BMF), also known as peripheral (pan) cytopenia due to inefficient hematopoiesis, is a reasonably common symptom in pediatric patients. Transient BMF in children is primarily caused by reversible factors including viral infections and nutritional deficits. Conversely, a wide range of underlying illnesses, including as malignancies, hereditary bone marrow failure syndromes (IBMFSs), and (idiopathic) aplastic anemia, are the cause of non-reversible BMF. Genetic abnormalities are thought to be the underlying cause of non-transient BMF in up to 50% of the cases (Vissers, 2023).

The diagnosis of pediatric BMF has improved recently. It is critical to identify patients with non-reversible BMF as soon as possible because doing so lowers the likelihood of invasive infections and bleeding problems while also enabling risk-adaptive cancer and organ surveillance as well as family counseling. Furthermore, it leads to the timely start of a treatment plan. Allogeneic hematopoietic stem cell transplantation (HSCT) is a major therapy option for the majority of BMF types, despite the fact that the etiology of non-transient BMF is very different (Vissers, 2023).

5.2 Computed Tomography (CT)

The term “computed tomography,” or CT, refers to a computerized X-ray imaging procedure in which a narrow beam of X-rays is aimed at a patient and quickly rotated around the body, producing signals that are processed by the machine’s computer to generate cross-sectional images (Cistaro, 2018). These slices are called tomographic images and can give a clinician more detailed information than conventional X-rays. Once several successive slices are collected by the machine's computer, they can be digitally "stacked" together to form a three-dimensional image of the patient that allows for easier identification of basic structures as well as possible tumors or abnormalities (Badr, 2016).

Diagnostic radiology has been transformed by computed tomography (CT) scanning, commonly referred to as CT imaging or just CT, which offers accurate and detailed imaging of internal body structures. CT scanning utilizes a combination of X-rays and computer algorithms to generate cross-sectional images, which can be reconstructed into three-dimensional representations (Elamir, 2020).

According to Hao (2018), each time the X-ray source completes one full rotation, the CT computer uses sophisticated mathematical techniques to construct a two-dimensional image slice of the patient. The thickness of the tissue represented in each image slice can vary depending on the CT machine used, but usually ranges from 1 to 10 millimeters. When a full slice is completed, the image is stored, and the motorized bed is moved forward incrementally into the gantry. The X-ray scanning process is then repeated to produce another image slice. This process continues until the desired number of slices is collected.

The first application of CT in an industrial context can be traced back to the 1980´s, in the field of nondestructive testing, where a small number of slices of the object were visually inspected. 3D quantitative industrial CT applications appeared in the late 1990s, with simple volume and distance analysis. Today, thanks to relevant improvements in both hardware and software, CT has become a powerful and widely used tool among non-destructive techniques, capable of inspecting

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external and internal structures in many industrial applications (Cantatore, 2011). CT is one of the most popular imaging techniques. But there can be a big difference in the caliber of CT scans done at various locations. To fully utilize CT, quality assurance (QA) must be closely monitored with regard to the operation of the equipment as well as the carrying out of imaging investigations (Dillon, 2017).

Elamir (2020) asserted that the development of more stable X-ray sources and better detectors led to the design of a more complex CT system, providing accurate geometrical information with micrometer accuracy. CT is widely used for the geometrical characterization of test objects, material composition determination, density variation inspection, etc. In a relatively short time, CT is capable of producing a complete three-dimensional model, and the tolerances of the scanned machined parts can be verified.

Because of the growing interest in precision in production engineering and an increasing demand for quality control and assurance, CT is leading the field of manufacturing and coordinate metrology. A key parameter. A key parameter for the reliability of the measurement process is the establishment of measuring uncertainty. Since there are many influence parameters in computed tomography, uncertainty contributors in CT and standards dealing with quantification of CT have not been completely established yet (Karak, 2018).

Computed tomography (CT) is a powerful tool capable of inspecting external and internal structures in many industrial applications as well as providing accurate geometrical information with high accuracy. A CT system contains of an X-ray

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source, a rotary table, an X-ray detector, and a data processing unit for computation, visualization, and data analysis of measurement results (Yilmaz, 2017).

In principle, CT creates cross-section images by projecting a beam of emitted photons through one plane of an object from defined angle positions and performing one revolution. As the X-rays (emitted photons) pass through the object some of them are absorbed, some are scattered, and some are transmitted (Karak, 2018). The process of X-ray intensity reduction involving just those X-rays that are scattered or absorbed is called attenuation. X-rays that are attenuated due to interactions with the object do not reach the X-ray detector. Photons transmitted through an object at each angle are collected on the detector and visualized by the computer, creating a complete reconstruction of the scanned object. The 3D gray value data structure gained in this way represents the electron density distribution in the measured object.

Piccardo (2019) confirmed that the assessment of bone marrow involvement is important in the management of lymphoma patients, as it is a sign of advanced disease. One of the common techniques for evaluating bone marrow disorders is computed tomography, or CT. Finding the number and location of bone lesions using advanced imaging techniques is the main duty of radiologists. MRI of the spine or pelvis is the gold standard for determining bone marrow DI. CT is utilized for assessment more often than routine MRI because it has a larger field of view (FOV) and is more easily accessible than whole-body MR imaging. With its high sensitivity to BMI, CT can be used to measure BMI precisely in patients with diffuse large B-cell lymphoma (DLBCL) and HL, potentially enhancing the results of routine iliac

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crest biopsies. A typical iliac crest biopsy is not required for the evaluation of HL if CT is performed.

According to previous studies, the diagnostic method of positron emission tomography (PET) using the tracer 2-(18F) fluoro-2-deoxy-D-glucose (FDG PET) is functionality based on the concept that rapidly developing cancer cells have improved glucose metabolism, facilitating detection of areas with cancer cells. Integrated FDG-PET/computed tomography (CT) had been developed to address the drawbacks of FDG-PET scanning (poor anatomical information), and it was widely used for staging planning radiation fields. and it was widely used for staging, planning radiation fields in cancer management, or determining the extent of surgical resection. Anatomical and functional information can be obtained in co-registered pictures using the computed tomography method, which scans the entire body in a single session, which usually requires numerous sessions to scan the entire body and is, therefore, time-demanding. Therefore, time-consuming (Badr, 2016; Cantatore, 2011; Cistaro, 2018).

5.3 Magnetic Resonance Imaging (MRI)

MRI is a non-invasive imaging technique that uses no harmful radiation to provide detailed, three-dimensional anatomical images. It is frequently employed in the diagnosis, monitoring, and detection of diseases. It is predicated on advanced detection and excitation technologies. It works by stimulating and detecting the shift in the direction of the protons' rotating axis, which is present in the water that constitutes living tissues, using advanced technology (Abbas, 2023)

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A spectroscopic imaging method called magnetic resonance imaging (MRI) is utilized in medical contexts to provide images of the human body's interior. Nuclear magnetic resonance (NMR), a spectroscopic method for obtaining tiny chemical and physical information about molecules, is the foundation of magnetic resonance imaging (MRI). The first MRI examination was performed on a human being in 1977. One image took five hours to create (Alvaro, 2009).

According to Brandis (2022), a computer, radio waves, and magnets are used in the MRI radiology procedure to create images of body structures. The majority of the human body is made up of water and fat, which means that roughly 63% of the body is made up of hydrogen, a proton that is essential to MRI scanning. Magnetic resonance imaging (MRI) is more sensitive than conventional imaging for the early staging of high-intensity bone marrow involvement. Nevertheless, it lacks the ability to differentiate between recently discovered lymphomatous involvement and lingering or therapy-induced anomalies of bone marrow signal.

Protons in the body are forced to align with the intense magnetic field created by the powerful magnets used in MRIs. The protons are subsequently excited and spin out of equilibrium when a radiofrequency current is pulsed into the patient, pushing against the magnetic field's pull. The energy produced as the protons realign with the magnetic field can be detected by the MRI sensors when the radiofrequency field is switched off. The surroundings and the chemical makeup of the molecules affect how long it takes the protons to realign with the magnetic field and how much energy is released (Caranci, 2018).

A patient is put inside a big magnet to get an MRI, and they have to stay motionless the entire time to obscure the picture. To accelerate the rate at which

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protons realign with the magnetic field, a patient may receive intravenous contrast agents, which frequently contain the element gadolinium before or during the magnetic resonance imaging (MRI). The image gets brighter the faster the protons realign (Chan, 2016).

According to previous studies, scanners for magnetic resonance imaging (MRI) are very useful for imaging the body's soft tissues and non-boney areas. They are not subjected to the harmful ionizing radiation of X-rays, which is how they differ from computed tomography (CT). Because MRI provides a considerably clearer image of the brain, spinal cord, and nerves than standard X-rays and CT do, it is frequently used to assess injuries to the knee and shoulder. Aneurysms and tumors can be diagnosed via MRI, which can also distinguish between white and grey matter in the brain. When repeated imaging is needed for diagnosis or treatment, especially in the brain, magnetic resonance imaging (MRI) is the preferred imaging modality as it doesn't involve radiation or X-rays. MRIs cost more than CT scans or x-ray imaging, though (Forshult, 2007; Gupta, 2017; Chan, 2016).

Nascimento (2014) confirmed that functional Magnetic Resonance Imaging is one type of specialized MRI (fMRI.) This is used to view brain anatomy and identify regions of the brain that "activate" that is, require more oxygen when performing different kinds of cognitive tasks. It contributes to our understanding of how the brain is organized and may establish a new benchmark for determining neurosurgical risk and neurological state.

MRI uses a powerful magnetic field, but it does not release the harmful ionizing radiation that is present in CT and X-ray imaging. The magnetic field is strong enough to propel a wheelchair across the room and reaches beyond the

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machine to exert extremely strong forces on iron, some steel, and other magnetizable items. Before having an MR scan, patients should let their doctors know about any implants or medical conditions (Caranci, 2018).

The patient is not completely encircled by the open MRI machine since it is open on the sides rather than a tube that is closed at one end. It was created to meet the demands of patients whose size or weight renders a typical MRI impracticable, as well as those who find the narrow tunnel and noises of the scan bothersome. Modern open magnetic resonance imaging equipment yields superior images for most but not all kinds of tests (Sarmet, 2021).

Sharara (2023) argued that the majority of the time, magnetic resonance imaging (MRI) is only sensitive to one element hydrogen, which makes up over 60% of all biological organs. As a result, the biological samples that can be scanned are nearly endless. The only bodily tissue that produces a signal with a low amplitude by nature is bone tissue, which has more hydrogen that is tightly bonded than most other bodily tissues. While some components cannot be seen, others may have an impact on the imaging process.

Because the chemical and magnetic environments of hydrogen atoms in various tissues and substances change somewhat, an MRI image's contrast can be seen. Consequently, they will react to radio waves in the form of brief radio frequency (RF) pulses that are directed at the item under study in a somewhat different way. This allows for the detection of disease alterations deep within an organ. The main benefit of MRI over most other imaging methods is this (Alvaro, 2009).

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5.4 The Role of CT and MRI in Evaluating Bone Marrow Diseases in Children

Forty percent of the patients had distant metastases to the liver, lymph nodes, bone marrow, and bone. Metastatic bone-marrow is a symptom of advanced disease and is usually associated with a dismal prognosis (Marilyn, 1996). Minimal residual disease (MRD) in bone marrow (BM) is regarded as a reliable independent predictor of survival following immunotherapy. Because of its benefits for diagnosis, staging, and therapy monitoring in pediatric cancers, bone marrow biopsy (BMB) is currently considered the "gold standard" method for determining bone marrow involvement (BMI). However, the process is invasive and uncomfortable, particularly for young patients (Alvaro, 2009)

As a well-established technique for staging bone marrow illness, CT may be used in addition to or as a noninvasive substitute for BMB. The ability to see the complete bone marrow is one of CT's main benefits. In order to diagnose BMI in pediatric patients, computed tomography (CT) can evaluate a tumor's structural anatomy and amount of metabolic activity at the same time. In contemporary radiology, a computed tomography (CT) scan is an imaging method that is extensively utilized. It gives medical professionals precise cross-sectional images of the body, which they can use to diagnose and treat a variety of illnesses (Nascimento, 2014).

In contemporary radiology, CT scans are now considered an essential tool that greatly aid in diagnosis, therapy planning, and patient management particularly with regard to pediatric patients. Medical imaging has been transformed by its capacity to deliver precise anatomical images, facilitate sophisticated imaging techniques, and guide interventional operations. Children with bone marrow illnesses have benefited from CT scans because they have made accurate diagnoses possible, facilitated prompt interventions, and improved treatment planning (Hao, 2018).

Rapid diagnosis and characterization of pediatric bone marrow disorders facilitates clinician decision-making about necessary surgical procedures or other therapies. CT scans are essential for cancer diagnosis, staging, and treatment monitoring in the field of oncology. It helps with treatment planning and therapy evaluation by offering comprehensive details regarding the location, size, and involvement of surrounding structures of the tumor (Khan, 2023).

Interventional radiologists can accurately target lesions and traverse through intricate anatomical structures with the use of real-time imaging guidance. Aspirations, drainage operations, and CT-guided biopsies have become standard practices, offering pediatric patients precise and effective diagnostic and treatment choices (Piccardo, 2019).

The widespread use of CT scans in clinical practice can be attributed to their advantages, which include excellent spatial resolution, quick imaging, and wide availability. Patient safety is ensured by appropriate methods and guidelines, despite the existence of considerations such as radiation exposure and contrast agent usage. In order to give patients, the best care possible and enhance results in the field of radiology, healthcare professionals can still rely on CT scans as a useful tool for precise diagnosis, treatment planning, and intervention guidance (Muzahir, 2012).

The most sensitive imaging modality to assess the marrow is magnetic resonance imaging (MRI), and bone marrow illnesses in children are a common, occasionally surprise finding. However, radiologists with little experience may find it challenging to interpret these images. A precise diagnosis and treatment strategy

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for a variety of medical problems depend heavily on diagnostic radiology. Magnetic resonance imaging (MRI) has become one of the most effective and diverse imaging methods accessible. Strong magnetic and radio waves are combined in MRI to provide finely detailed images of inside body structures (Abbas, 2023).

Radiologists often come across tumor-like lesions including bone tumors. While radiographs are the main screening method, when a lesion is indeterminate or exhibits aggressiveness, magnetic resonance imaging (MRI) can help limit the differential or provide a precise diagnosis. MRI can show several tissue components, extending the diagnostic evaluation (Brandis, 2022).

According to Raissaki (2017), during any magnetic resonance imaging (MR) study, the bone marrow one of the biggest organs in the body is visible. Its composition varies throughout life in response to natural maturation (red-to-yellow conversion) and stress (yellow-to-red reconversion). It is made up of a combination of hematopoietic red marrow and fatty yellow marrow. Changes in the intensity of the marrow signal can be detected with great sensitivity using MR imaging, and the best contrast between disease-related and yellow marrow can be found using the T1-weighted spin-echo sequence.

When compared to other imaging modalities, MRI has a number of advantages. It is safe for both adult and pediatric populations due to its superior soft tissue contrast, multiplanar imaging capabilities, and lack of ionizing radiation. Additionally, functional and physiological imaging is made possible by MRI, which offers important insights into the properties of tissues and pathophysiological processes (Sarmet, 2021).

With its remarkable imaging powers and wide range of pediatric applications, magnetic resonance imaging (MRI) has completely transformed the diagnostic radiology sector. Its outstanding soft tissue contrast, non-invasive design, and multiplanar imaging capabilities have made it an invaluable tool for the diagnosis of pediatric bone marrow disorders. Accurate diagnosis and treatment planning are made possible by the comprehensive anatomical pictures of the spinal cord and bone marrow that are provided by MRI. Furthermore, a critical imaging technique for the examination of these injuries and the formulation of a suitable treatment plan is magnetic resonance imaging, or MRI. When an MRI is not done, the definitive diagnosis is frequently postponed (Abbas, 2023; Alvaro, 2009; Chan, 2016).

When doing magnetic resonance imaging (MRI) on patients who have suffered spinal cord injuries, it is crucial to correctly identify changes in the spinal cord signal and to use paramagnetic contrast. These techniques greatly enhance lesion delineation, lesion visualization, and the demonstration of activity within the lesion (in patients with inflammatory diseases). In addition to the standard acquisitions in the sagittal and axial planes, which are typically carried out at most centers, it is also crucial to obtain pictures in the coronal plane (Nascimento, 2014).

5.5 Previous Studies

In a study entitled **“The Role of CT Scan in Modern Radiology: From Diagnosis to Treatment Planning”** conducted by Khan et al (2023) aimed to examine the various uses of CT scanning in contemporary radiology, emphasizing its function in patient care, diagnosis, and treatment planning. The earlier research on the factors used in this study was necessary. The findings showed that CT scans are still a useful tool for precise diagnosis, treatment planning, and intervention

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guidance, allowing medical practitioners to enhance patient outcomes and give the best possible care.

Another study entitled **“FDG-PET/CT versus bone marrow biopsy in bone marrow involvement in newly diagnosed pediatric lymphoma: a systematic review and meta-analysis”** conducted by Zhizhuo Li (2021) while it can be quite difficult at the moment, it is crucial to attempt to detect pediatric lymphoma patients as soon as possible using their BMI. Research was methodically obtained from the Cochrane Library, EMBASE, and PubMed. The quality assessment and data extraction were carried out independently by two reviewers. The quantitative analysis includes nine eligible research in total. According to the findings, FDG-PET/CT had a pooled sensitivity and specificity of 0.97 (95% confidence interval [CI], 0.93 to 0.99) and 0.99 (95% CI, 0.98 to 0.99) for identifying BMI in pediatric lymphoma patients who had just received a diagnosis.

A study entitled **“Clinical utility of 18F FDG-PET/CT in the detection of bone marrow disease in Hodgkin's lymphoma”** conducted by Muzahir (2012) sought to assess if fludeoxyglucose (FDG)-positron emission tomography (PET)/CT could be used to diagnose bone/marrow disease in individuals suffering from Hodgkin's lymphoma (HL). The 122 newly diagnosed, biopsy-proven cases of HL with (18F)-FDG-PET/CT scans conducted between November 2009 and June 2010 were retrospectively examined in this investigation. According to the results, 85 individuals, or 69.7%, had PET/CT results that were negative for bone or bone marrow involvement, while the remaining 37 patients had aberrant FDG uptake.

A study entitled **"The Role of Magnetic Resonance Imaging (MRI) in Diagnostic Radiology"** conducted by Abbas and Nawaz (2023) intended to examine the benefits, drawbacks, and uses of magnetic resonance imaging (MRI) in diagnostic radiology. The earlier research on the factors used in this study was necessary. The findings showed that MRI is anticipated to further enhance patient outcomes, treatment planning, and diagnostic accuracy as technology advances. Overcoming obstacles pertaining to expense, proficiency, and patient characteristics will support the expansion of MRI use and accessibility in diagnostic radiology, guaranteeing its ongoing influence on enhancing patient care.

Another study entitled **"Pediatric Bone Marrow MR Imaging"** conducted by Alvaro and Paul (2009) aimed to provide an overview of the current use of MR imaging in the evaluation of pediatric bone marrow disorders, and illustrate their appearance on commonly used MR imaging sequences. This study depended on the previous studies related to its variables. The results indicated that MR plays an integral role in the detection and characterization of bone marrow lesions, guiding biopsy, staging, treatment planning, and in following therapy-related changes.

Lastly, a study entitled **"Whole body magnetic resonance imaging in healthy children and adolescents: Bone marrow appearances of the axial skeleton"** conducted by Brandis et al (2022) aimed to describe the findings of focal high signal on T2 weighted (T2W) images of the bone marrow in the axial skeleton as assessed by whole-body MRI in healthy and asymptomatic children and adolescents. The study assessed the bone marrow of the mandible, shoulder girdle, thorax, spine, and pelvis on water-only Dixon T2W sequences as part of a whole-body MRI protocol in 196 healthy and asymptomatic children aged 5–19 years. Intensity (0–2 scale) and extension (1–4 scale) of focal high signal areas in the bone marrow were scored and divided into minor or major findings, based on intensity and extension to identify the potentially conspicuous lesions in a clinical setting. The results registered 415 areas of increased signal in the axial skeleton where 75 (38.3%) were major findings. Fifty-eight (29.6%) individuals had at least one major finding, mainly located in the pelvis (54, 72%). We found no differences according to gender.

6. Methodology

The current research will adapt the descriptive approach through reviewing previous studies that related to the topic variables.

7. Conclusion and Recommendations

A bone marrow examination is essential to increase the patient's long-term survival and minimize any possible hematologic, bone, and neurological issues. The effects of significant bone marrow disorders, including bone and marrow deposits, can be observed using specific radiological techniques. Physicians use CT and MRI scans for better characterization and accuracy when treating non-specific diseases or those that exhibit aggressive symptoms.

Numerous illnesses may be the cause of children's polyostotic bone and bone marrow lesions. The use of computed tomography (CT) and magnetic resonance imaging (MRI) for the identification, characterization, and monitoring of bone marrow lesions in children with illnesses and ailments that may impact the bones or bone marrow has increased.

However, novice radiologists may find it challenging to interpret these findings. The risk of death and skeletal-related events (SREs) was consistently higher when bone metastases were present. SREs have been associated with increased morbidity, higher treatment costs, and lower quality of life. According to previous studies, there is a lack of studies with the same variables involved in the research topic. The researcher applied the descriptive approach by reviewing previous studies related to the dependent and independent variables of research. Therefore, the researcher recommends the following recommendations:

1. Additionally, special care must be taken when imaging vulnerable populations, such as pregnant women or pediatric patients, to minimize radiation risk.
2. Efforts are being made to optimize imaging protocols and minimize radiation dose while maintaining diagnostic image quality.
3. Knowledge of normal age-related BM appearance, normal variants, and patterns of involvement in focal and diffuse bone diseases is essential, together with clinical and laboratory data, to narrow the list of possible differential diagnoses.

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