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A REVIEW OF THE COLLECTION OF IMAGE RADIOGRAPHIC FEATURES OF PELVIC BONE TUMORS

Mona Shouman[(1)], Kamel Hussein Rahouma[(2),] and Hesham F. A. Hamed[(3)]

Computer and System Engineering Department, Faculty of Engineering, Minia University, Minia, Egypt[(1)]
Faculty of Engineering, Minia University, Minia, Egypt
Vice Dean of the Faculty of Computers, Nahda University, Beni Suef, Egypt[(2)]
Faculty of Engineering, Egyptian- Russian University, Cairo, Egypt
*Corresponding author *E-mail*: mona.shouman1985@gmail.com

ABSTRACT

Pelvic bone tumors are difficult to locate on radiographs because of the low sensitivity of basic radiographic detection. Additionally, a simple radiograph cannot show cortical destruction, significant periosteal reaction, or a major soft tissue component, with or without calcification. CT or MRI is found to be better at characterizing tumors and extracting many radiographic features. The most important tool is an MRI, which is utilized for diagnosis, therapy monitoring, and recurrence detection. But a biopsy is required to get a more precise diagnosis. It was discovered that there are not many databases dedicated to these cancers. Building a database with all the radiographic characteristics of cancers was motivated by this study. As a result, the study's main objective is to make review research on pelvic bone tumors to build this database. Creating a taxonomy that organizes past studies on pelvic bone tumors is another objective. In this study, a certain research approach that the researchers had already authorized was applied. As a result, we were able to produce tables that show a tumor's radiographic features and whether it is benign or malignant. If the tumor is malignant, these tables also show its stage. This research is a component of the development of diagnostics using artificial intelligence as the type of tumor and its stage may be determined by artificial intelligence using this database through deep learning or machine learning, which will make the work of doctors easier with accuracy 100%.

Keywords: radiographic features, pelvic, pelvic bone tumors, pelvic metastases, artificial intelligence

1. INTRODUCTION

One of the least common neoplasms in humans is a bone tumor. They represent 0.8–1% of all new cases of cancer that develop in the body. [1]. Different forms of bone cancer are recognized, and they are frequently treated in various ways. To create the best treatment strategy, it is important to determine the specific type of bone cancer. Some tumors that are benign (not malignant) and may be surgically removed do not spread to other tissues or organs. They frequently do not represent a risk to life.

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Sarcomas are malignant tumors that start in the bone itself, making them real (or primary) bone tumors Bone, muscle, fibrous tissue, blood vessels, fat tissue, and other tissues are just a few of the tissues in which sarcomas can develop. Many advanced malignancies, such as lung, prostate, and breast cancers, have the ability to metastasize to the bones.

This study aims to facilitate the work of other researchers and can be used as a starting point. This article is a collective hard work spent searching a database for pelvic bone tumors. It became clear that there are few databases for these tumors. This was the motive to create a database that involves all the radiographic features of tumors. Therefore, the main objective is to make a review of the existing research in the last five years on pelvic bone tumors.

Moreover, creating a taxonomy that collects the previous work of many researchers about pelvic bone tumors and their stages. This study involved a specific research method was followed that was agreed upon by the researchers previously. We were concerned with the stage of each tumor, the type of patient, whether male or female, as well as the age of the patient which is critical to determine the type of bone tumor. Thus, we were able to form tables for the classification of tumors showing the radiographic features whether the tumor is benign or malignant. Furthermore, these tables show the stage of the malignant tumor.

This article is divided into six sections. The introduction gives an explanation of the study's purpose and motivation. The second part has all the previous articles on bone tumors' reviews. Then the methodology illustrates the taxonomy of tumors. The fourth part is showing all results. Then the fifth part is the discussion. The conclusion is the last part.

2. LITERATURE REVIEW

There are few studies that have provided a review or survey of bone tumors. The range, prevalence, and demography of bone cancers were illustrated in 2006. In addition, the gender, age, and geographic distributions of bone cancers are displayed. From 2000 to 2004, a conducted of a retrospective analysis of the 1,001 bone tumor specimens stored in the pathology department's records at the Chiang Mai University Hospital in Thailand was done [2]. In addition, in 2008 a summary was provided of the peak age predilection of bone lesions, typical bone lesion sites, tumors with an appearance of being penetrated or moth-eaten by age, numerous bone lesions (sclerotic or lytic), and lytic expansile soap bubble look [3]. Moreover, primary benign osseous bone tumors and pseudo-tumors of the proximal femur are presented in 2012 together with the prevalence of primary osseous bone tumors of the pelvis. The prevalence of sarcoma in the proximal femur was also demonstrated. Also, a review of hip and pelvic bone and soft tissue cancers was published. [4].

3. METHODOLOGY

Numerous investigations have found that bone sarcomas are the most common lesion, followed by soft tissue sarcomas and metastatic lesions [5]. Following Chondrosarcoma (cartilaginous origin), osteosarcoma is the second most frequent pelvic sarcoma [6,7,8]. Pelvic bone cancers most often affect the iliac bone, next the ischial bone, the ill pubic ramus, and the acetabulum [6].

Data and illustrations used for this review are extracted from available papers and books in the period from 2018 to 2022. Pelvic bone tumors are difficult to detect on radiographs, and there should prefer to go to CT or MRI. The general anatomy of the pelvic bone is discussed in this study. It is important to realize the location of the tumor in the pelvic region: the iliac, pubic, and ischial bones, the proximal femur with its secondary growth centers, and the components of the sacrum. Due to the complicated anatomy, certain areas of the body have thick bones and others have thin bones (particularly in the proximal femur and iliac wing), which may both be misleading on conventional radiographs. Osteolysis may be misinterpreted for the typically related characters in the Wards triangle of the proximal femur, for instance. Additionally, the findings from the iliac bone's core, which is also very thin, maybe misunderstood for an osteolytic tumor, especially if extra bowel gas is projected over the iliac wing. The simplest way to deal with this is to identify all of the cortices of the neural foramina. Bowel gas is another significant factor in missing malignancies in the sacrum [9]. Surgery for pelvic tumors is more difficult than for the appendicular skeleton. Pelvic tumors are often bigger when they are diagnosed [10].

Some tumors affect males more than females and vice versa. It is also very important to know the age of the patient, as age can determine the type and degree of the tumor. So, for pelvic bone tumors, age is a very important clue in diagnosis. Such as Eosinophilic Granuloma (EG) affects males more than females and the patient’s age is bigger than 12 years old. So, there are many clues that are very important to the diagnosis of bone tumors.

The shape of the bone lesion on a plain radiograph, whether it is well-defined osteolytic, ill-defined osteolytic, or sclerotic, and the patient's age is the most crucial factors in the examination of a probable bone malignancy. Osteolytic bone cancers dominate. Figure 1 depicted the anatomy and shape of the bone lesion. The next consideration should be the patient's age once we have determined if a bone lesion is sclerotic or osteolytic and whether its edges are well-defined or ill-defined. The most significant clinical indicator is age [11].

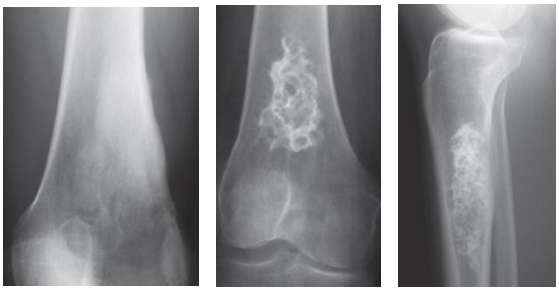


Figure 1: a) A sclerotic lesion with an ill-defined appearance characterizes the Periosteal sarcoma., b) An osteolytic bone lesion and well-defined also, c) An ill-defined osteolytic bone lesion presents Osteosarcoma [12]

When examining a bone tumor, the patient's age is the most important piece of clinical data since most bone malignancies are more common in a particular age range [2]. Age groups can be divided in a variety of ways, as seen in figure 2. Some people like to split up the patients into two age groups: 30 and older. For people older than 30 years, the differential diagnosis must always include metastases and myeloma.

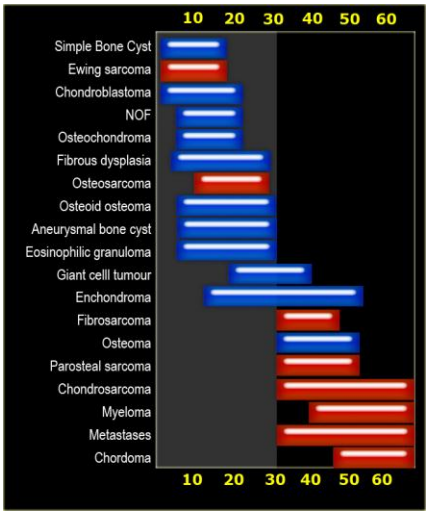
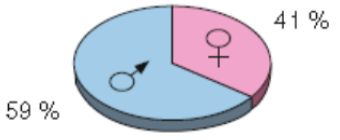
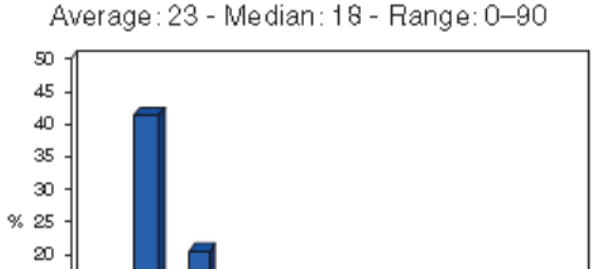


Figure 2: Specific tumors by age malignant bone tumors in red and benign tumors in blue [11]

n benign tumors, the ratio of men to women is (1.5:1). Age, with an average age of 18 years, comprises the first four decades of existence. They are rather rare in the elderly (figure 3). Malignant tumors have a male-to-female ratio of 1.5:1, similar to benign tumors. The median age is 25 according to Figure 4, with a rise in the second and third decades of life [13].





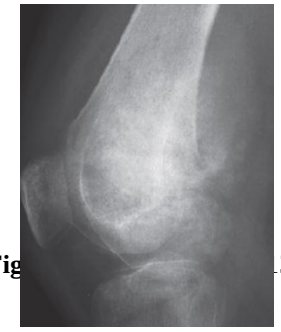
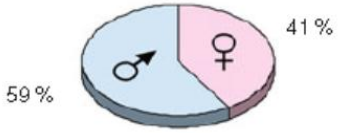


Fig 3]



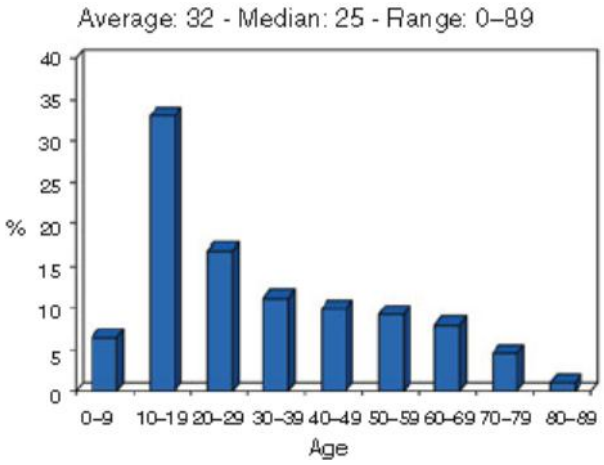


Figure 4: malignant tumors [13]

The zone of transition between the osteolytic lesion and the nearby normal bone is the third clue. The boundary between the lesion and the normal bone is known as the zone of transition. It is a narrow zone of transition if the lesion is benign and well-defined (has a sclerotic border). The lesion is undetectable (aggressive) if the zone of transition is wide (benign or malignant), as seen in figure 3. Both Infection and Eosinophilic Granuloma have a wide transitional zone and are aggressive while being benign. Looking at the zone of transition is the most reliable technique to tell if a lesion is benign or malignant. If a tumor has several little holes throughout it, it is considered to be permeative (figure 4). With no visible boundary, primary lymphoma and Ewing sarcoma have a wide zone of transition. Only lytic tumors are affected by the zone

of transition. A sclerotic lesion will always have a narrow zone of transition [12].

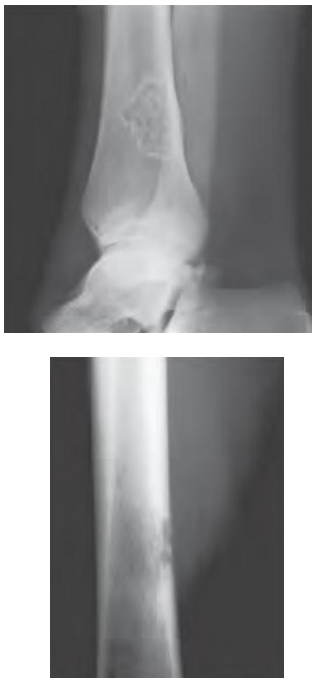


Figure 3: a) a narrow zone of transition, b) a wide zone of transition [12]

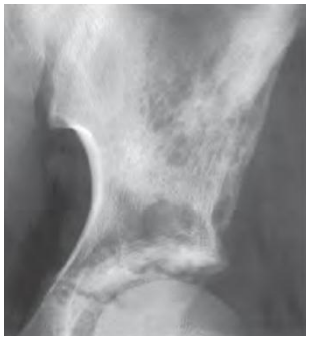


Figure 4: permeative pattern [12]

The biological characteristics of a bone neoplasm can be interpreted very well by the periosteal reaction [13]. The fourth clue is a non-specific reaction known as a periosteal reaction that will take place if the periosteum is impacted by a benign tumor, malignant tumor, infection, or trauma. This reaction is seen in Figure (5,6,7). A benign kind of periosteal reaction is a thick, wavy, and uniform callus production that is sustained by chronic irritation. There are two types of periosteal reactions: not aggressive and aggressive. The benign type is present after trauma and in benign lesions like benign tumors. Malignant tumors, including Infections and Eosinophilic Granulomas, can exhibit aggressive action. In the case of benign, slowly developing lesions, the periosteum has time to build down thick new bone and change the lesion into a more normal-appearing cortex. A lamellated, multilayered, or bone-growing response perpendicular to the cortical bone may be seen in an aggressive periosteal reaction. It might be conjectured and interrupted; occasionally, a Codman's triangle will show up. When the raised periosteum and bone come together, an angle called a Codman's triangle is created. When the periosteum is raised away from the cortex, it happens. Roentgenographically, periosteal reactions can be classified as (I) solid or (II) interrupted table (3.1) [14].

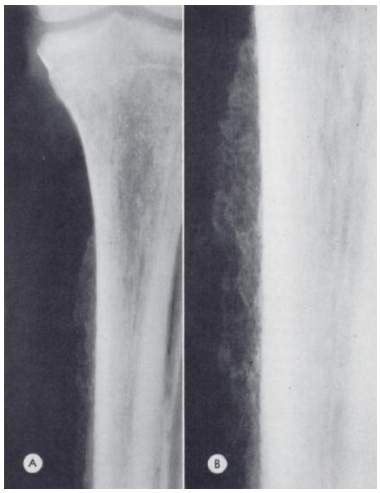


Figure 5: Pulmonary osteoarthropathy leads to a dense undulating periosteal reaction. It is irregularly calcified and thick. (A) Standard roentgenogram. (B) Magnified roentgenogram [15].

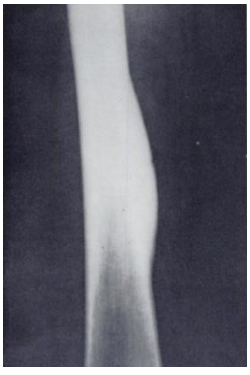


Figure 6: Osteoid osteoma has a dense elliptic periosteal reaction. It is benign because of the solid nature of the reaction [15].

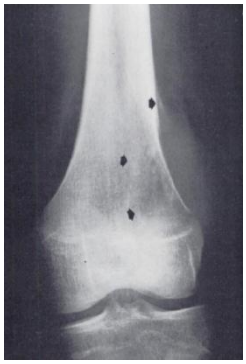


Figure 7: Osteosarcoma with Codman's triangle and osteolytic lesion [15].

Table (3.1): Periosteal reactions [15]

Type	Example
I.	**Solid Periosteal reaction**
Thin	Eosinophilic Granuloma and Osteoid Osteoma
Dense Undulating	Vascular
Thin Undulating	Pulmonary Osteoarthropathy
Dense Elliptic	Osteoid Osteoma
With Destruction	Malignant tumors
Cloaking	Storage diseases, Chronic infection
Codman's Triangle	Hemorrhage and Malignancy
II.	**Interrupted Periosteal reaction**
Lamellated (Onion Peel)	Osteosarcoma, Ewing's tumor and infection
Perpendicular (Sunburst)	Osteosarcoma, Ewing's tumor and infection
Amorphous	Malignant tumor

Although cortical destruction is a frequent observation, it is not especially useful in identifying benign or malignant lesions. Destruction may be brought on by high-grade malignant tumors as well as locally aggressive benign lesions such as EG and osteomyelitis. In benign and low-grade malignant lesions, the loss of cortical bone is more uniform. Figure 6 in the images shows irregular cortical destruction in Osteosarcoma and cortical destruction with severe periosteal response in Ewing's sarcoma. However, it remains a tip for identifying the kind of tumor [11].

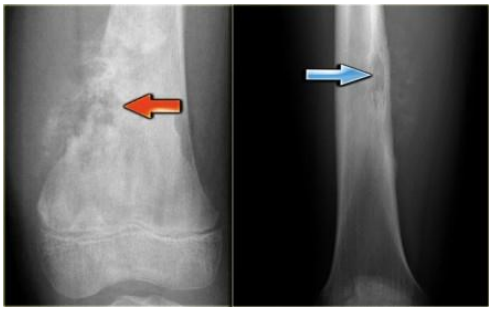


Figure 6: Osteosarcoma (left) and Ewing's sarcoma (right) [11]

The presence of matrix calcifications or mineralization within a bone lesion may be a crucial sign in the differential diagnosis. There are two different types of mineralization: an osteoid matrix in osseous tumors like osteoid osteomas and osteosarcomas, and a chondroid matrix in cartilaginous tumors like enchondromas and chondrosarcomas. There are several ways to describe the chondroid matrix calcifications found in chondroid tumors, including rings-and-arcs, popcorn, focal stippled, and flocculant. Figure 7 shows the chondroid matrix calcifications. In benign bone-forming lesions, osteoid matrix mineralization is described as a trabecular ossification pattern, while in Osteosarcomas, it is described as a cloud-like or ill-defined amorphous pattern. Sclerosis can also be recurrent, as in Lymphoma or Ewing's sarcoma. Figure 8: Left, Bone development that resembles clouds in osteosarcoma [11].

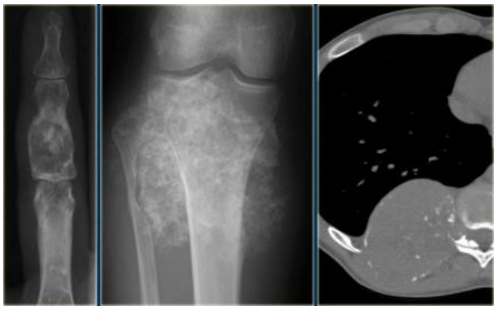


Figure 7: Chondroid matrix. left: Enchondroma, middle: Peripheral chondrosarcoma, right: Chondrosarcoma of the rib [11]

Figure 8: Osteosarcoma with osteoid matrix (left) and osteoid osteoma (right) [11]

Staging for bone malignancies and type of tumor considers the location of the tumor. The picture in figure 9 depicts where the majority of bone cancers like to grow. Nearly all bone cancers may be

seen in some regions, such as the humerus or the area surrounding the knee. Additionally, the pelvis has some tumors like EG, Lymphoma, and Osteosarcoma. The specific location of the tumor is well-examined on MRI. On MRI, soft tissue involvement, skip metastases, intramedullary extension, and extension to vessels and nerves are all easily recognizable. The main disadvantage is an articular extension, which might change the surgical strategy: if the tumor reaches the cartilage, it is impossible to predict with any degree of certainty how the joint would be affected. Although CT is used, it is less reliable when there are restrictions (pacemakers and metallic ocular foreign bodies). Numerous lesions and bone metastases can be identified on scintigraphy. Total body MRI is more sensitive without radiation. Pulmonary metastases are searched for on a chest CT. A thorough assessment of the patient is now possible thanks to the combination of PET and CT, which looks at the tumor's distal spread as well as its metabolic activity [13].

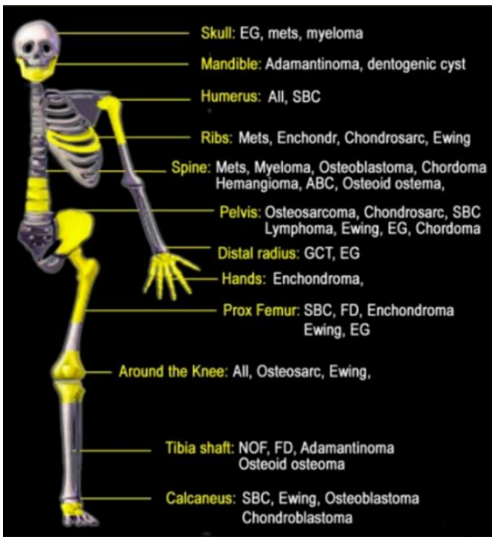


Figure 9: Location within the skeleton [11]

Cancer tumors are categorized in malignant tables using the American Joint Committee on Cancer (AJCC) staging approach. Roman numerals from I to IV are used to identify the stage for the majority of cancers; stage IV is the highest and denotes a more advanced stage of the disease than previous stages. Phases can also be divided using letters like A and B [16].

For pelvic:

Stage 1: The tumor is non-aggressive and only affects one area of the pelvis.

1a: The tumor measures 8 cm or less.

1b: The tumor is beyond 8 cm in size.

Stage 2: The tumor is only present in one or two pelvic regions, depending on whether there is an extraosseous extension. The malignancy is also aggressive.

2a: Tumor size is 8 cm or less in 2a.

2b: The tumor is beyond 8 cm in size.

Stage 3: The tumor has extraosseous expansion and is located on two portions of the pelvis.

3a: The tumor measures 8 cm or less.

3b: More than 8 cm of the tumor is present.

Stage 4: The tumor has spread to three areas of the pelvis or has penetrated the sacroiliac joint, which joins the pelvis to the base of the spine. This indicates that the disease has spread to further body parts.

4a: The tumor has spread to the sacral neuroforamen and affects the sacroiliac joint.

4b: The tumors affecting blood flow or have encroached on blood arteries.

Pelvic bone tumors are benign or malignant. The benign tumors are Osteochondroma, Eosinophilic Granuloma (EG), Periosteal chondroma or Juxtacortical chondroma or Parosteal chondroma, Chondromyxoid fibroma (CMF), Desmoplastic fibroma or Collagenous fibroma, Benign fibrous histiocytoma (BFH). While the malignant tumors are primary: Osteosarcoma (OS), Chondrosarcoma (CHS), Ewing's sarcoma (ESFT), Chordoma, Lymphoma, Angiosarcoma, Hemangiopericytoma or Musculoskeletal hemangiopericytomas, metastatic bone carcinoma [17].

Males are more commonly affected than females by an Osteochondroma, which is solitary and has moderate T1 and high T2 signal intensity [18]. The lesion will manifest as a bony protrusion from the bone of origin, which may have a narrow or broad base and a continuous cortex underneath it. It is often found between the ages of 6 and 20 [19]. It is distinguished by an external cancellous structure, a bony protuberance with clear boundaries, and a thin outer cortex. It possesses calcified cartilage, localized bone trabeculae thickening, and bone necrosis. Some are pedunculated, either with pointed, horn-like extremities pointed, horn-like extremities or a globose, cauliflower-like top. Its size ranges from 15 to 20 cm. Radiological features include solitary lesions and cartilage cap thickness of more than 2 cm in adults and 3 cm in children [20]. The lesion's cortex and medulla, which are continuous with the underlying bone and vary in size from 1 to 10 cm, are present. The tumor is a distinct protuberance on an otherwise cartilaginous bone that continues into the cortex and marrow of the parent bone. The cartilage cap produces a low-intermediate signal on T1-weighted images but a high signal on T2-weighted imaging. It might be sessile or pedunculated [15].

A lytic bone lesion, bone destruction, osteolysis with irregular borders, and a lack of dead bone in the affected area are all characteristics of Eosinophilic Granuloma (EG) tumors [21]. On T2-weighted images, high-intensity signals, as well as low-intensity signals, are seen. The edges of EG tumors may be scalloped, beveled confluent, show a sequestrum that resembles buttons, or beveled with the surrounding soft tissue mass. The EG tumor destroyed lytic bone by perforation or osteolysis [22]. More men than women are affected. In contrast to the degree of bone damage, the periosteal reaction was continuous and natural, and the layers were often more parallel and evenly distributed. Soft tissue mass and osteolytic damage were also seen. The hyperintense osteolytic lesion, soft tissue mass, and lytic lesion of the EG tumor are well-defined [23].

Periosteal chondroma show as one or more cortically situated, lobulated soft-tissue masses with cortical cauterization or erosion [18]. Periostitis and medullary sclerosis could also be present. Chondroid calcifications and cortical buttressing and thickening are seen. The only people who typically get Periosteal chondroma are children and young adults [24]. It shows uniform borders and superficial erosion of the bone cortex, along with maybe some minor scalloping. A hemispherical, often small to moderately sized (3 cm) periosteal cartilaginous mass is what causes this erosion. The tumor may have granular or popcorn densities carried on by calcifications. A Parosteal chondroma tumor is a lobulated, exophytic metaphyseal mass with soft tissue components showing central ossification [25]. A thin radiolucent cleavage plane with a wide or narrow "stalk" of attachment separates the lesion from the bone. Rarely, the periosteal reaction may manifest as an incomplete, thick, or uneven cartilage cap.

Chondromyxoid fibroma (CMF) tumor has a cortical lesion, lytic with periosteal reaction, and soft tissue on the cortical surface [26]. Additionally, it has a well-defined sclerotic border and interior calcification. Chondromyxoid fibroma is composed of lobulated and chondroid tissues (CMF) [19]. It appears between the ages of 5 and 30, is quite rare, and prefers men. Due to a sclerotic rim, it is tiny (typically 5 cm) and heavily marginated by an endosteal reactive bone shell. Frequently, the cortex is canceled, which causes the tumor to "bubble out" into soft tissue. Intratumorally calcification and little chronic peripheral periosteal reaction are uncommon. In a worldwide lytic lesion in CMF, expansile remodeling and typically coarse trabeculation have been seen [12]. An unidentified lesion with high T2 and low T1 signal intensity is detected by MRI.

Lesions of Benign fibrous histiocytoma (BFH), also known as a Desmoplastic fibroma or Collagenous fibroma, often thin and slightly expand one cortical surface [27]. The inner border has a clearly defined, slightly scalloped margin that is suggestive of a nonaggressive lesion. There is no periosteal reaction. Rarely many lesions can appear together. Desmoplastic fibromas are more common in males than females [19]. The majority of cases were diagnosed when they were less than 30 years old. The radiographic image displays significant osteolysis, often accompanied by bone expansion. A thin bony shell that has just developed might take the place of the original cortex. The tumor sometimes and focally penetrates the cortex without a clear border toward the surrounding tissues. Osteolysis frequently appears as finely trabeculated, reticulated, or bubbly tissue. The edges of the tumor may develop a rind of sclerosis as a result of reactive chronic hyperostosis. The tumor only minimally absorbs contrast on angiography and CT, and it has a comparatively "cool" appearance on isotope scans. MRI results in low T1 and T2 signals. According to observations, desmoplastic fibromas show a lytic, frequently well-defined, lobulated lesion without peripheral sclerosis or periosteal reaction [12]. A developing tumor may damage the bone's cortex and slightly enlarge the soft tissue surrounding the lesion.

Less than 0.2% of all malignancies are primary bone cancers [28]. Between the ages of 5 and 14, Osteosarcoma (OS) is also more common in children and young adults, peaking in people over 65. Osteosarcoma (OS), which also exhibits a second spike in the seventh and eighth decades, is the most prevalent primary malignant bone tumor in children aged 15 to 19 years [29]. Anyone over the age of sixty who has a history of Paget's disease is more prone to develop OS, especially pelvis, and lung metastases. Primary OS is more prevalent in older patients who are male, affects white males more frequently, and attacks black boys more often [30]. 25% of pelvic tumors are malignant. A majority of them have lytic lesions with cortical breakthrough, expansion into nearby soft tissues, and varied periosteal reactions. A reliable radiographic diagnosis is typically additionally supported by severe lytic bone destruction, osteoblastic matrix, extraosseous extension, Codman's triangle, and periosteal response. Soft tissue invasion into the cortical bone and soft tissue mass is a feature of Osteosarcoma (OS) tumors [30]. Soft tissue masses in OS are 5.9 ± 2.4 in size (3.9–8.0 cm) [24]. When the tumor enters the brain, OS is thought to be localized in the pelvic ilium, and the tumor's soft tissue extension exhibits irregularity, the Codman's triangle arises. [25]. Sclerosing OS had a low intensity on both T1 and T2

imaging, in contrast to the normal OS, which has a low T1 and high T2 signal. Pelvic Osteosarcomas frequently have higher volumes and are found later than those that form in long bones because of their deep placements [31].

The ring-and-arc patterns of the sclerotic areas show that the chondroid matrix is present in the soft tissue mass of Chondrosarcoma (CHS) tumors. [32]. They affect more men between the ages of 30 and 60 [33]. Soft tissue masses and a cancerous cortex with endosteal scalloping are seen in the tumor. The cartilage portions of the tumor display high signal intensity on T2-weighted images, but only low signal intensity on T1-weighted images. A mixed lytic-sclerotic lesion, less-calcified foci of moth-eaten or permeative pattern, and lobulated endosteal scalloping that finally leads to cortical penetration are other possible characteristics of CHS [34]. The mean age of dedifferentiated chondrosarcoma was 50.39 years. More men than women and those over 50 were impacted. Dedifferentiated chondrosarcoma most frequently affects people in their sixth decade of life. An apparent sclerotic boundary with or without a large transition zone, moth-eaten cortical disintegration, and extra-osseous soft tissue are all present [32]. Sites of matrix mineralization additionally displayed lobulated, uniformly hyperintensity with low signal intensity septum in addition to foci of signal void shown on T2 weighted sequences. The cortex is being destroyed by tumors, which are also affecting the soft tissues and dissolving the calcifications. Dedifferentiated CHS could exhibit properties such as cortical thickening, endosteal scalloping with chondroid calcification, and elongated multilobulated osteolytic foci that are comparable to low-grade Conventional CHS. The non-cartilaginous zone grows and the quantity of bone lysis rises as the illness gets better, a sign of insufficient matrix mineralization [33]. There is no difference for either gender or age when it comes to the highly rare Mesenchymal Chondrosarcoma. They are cortical-penetrating osteolytic lesions that are permeative and destroy the bone. They also include soft tissue bulk and disappearing typical calcifications. For patients with Mesenchymal Chondrosarcoma, the average tumor size was 10.2 ± 7.2 cm overall, 7.1 ± 7.3 cm in those without metastases, and 13.2 ± 5.9 cm in those with metastases [34]. Malignancies also show extensive soft tissue extension, cortical destruction, chondroid calcifications, and severe lytic bone lesions. Matrix mineralization is higher in Conventional CHS than in CHS. Traditional CHS tumors contain calcification in the form of popcorn. Conventional chondrosarcoma often appears during the fifth and seventh decades of life. It shows up as lytic, expansile, intramedullary lesions with cortical thickening, chondroid calcification, soft tissue mass, and cortical destruction. No aggressive periosteal response will occur. The tumor appears as an intermediate signal on T1-weighted images and as a lobulated, strong signal on T2-weighted imaging. Matrix calcifications will provide a similarly low signal on all sequences [18]. Periosteal chondrosarcoma can strike adults in their second through fourth decades of life, with males having a higher risk than women. Periosteal chondrosarcoma is an uncommon adult condition in which the lesion is > 5 cm in diameter. A tumor mass may be radiolucent or contain granules, rings, cartilage areas, or, less commonly, clusters of fading ossifications on the cortex's outer surface. Sharp edges, an interior sclerotic rim, an outer cortex that resembles a saucer, a neighboring cortex that is thick, and a buttress of periosteal reaction. Radiographs reveal a radiolucent lesion with scalloping of the underlying cortex and underlying sclerosis [8]. Dedifferentiated CHS patients are about 60 years old, and they commonly have CHSs that are around 4 cm larger than their core CHSs (half of them are more than 10 cm) (around age 51) [33].

Men are affected by Ewing's sarcoma (ESFT) somewhat more commonly than women, and the majority of patients are under 20 [8]. A tumor often comprises a mass that is destructive, a periosteal reaction that is aggressive, and a soft tissue component with a weak margin. Although high T2 signal intensity areas are rarely achievable, regions with intermediate T1 and low to moderate T2 signal intensities are often associated with calcification. Studies have shown that ESFT tumors have an aggressive periosteal reaction that can give them an onion-skin or hair-on-end appearance [35]. The majority of patients experience soft tissue masses along with lytic or mixed lytic and sclerotic lesions. There is calcification in the Ewing's sarcoma (ESFT) [36]. At T1/T2 intermediate signal intensity, the Ewing's sarcoma (ESFT) tumor's boundary is asymmetric [19].

Osteolysis-related Chordoma tumors have rounded, lobulated, well-defined margins and a thin reactive sclerosis rind [19]. As a result of calcification and ossification at the cartilage lobule borders, lesions frequently have granular, popcorn-like ring-like opacities. A low signal in T1, a high signal in T2, and black signal gaps in both T1 and T2 are signs of calcification. Although it may afflict anybody at any age, the majority of chordoma cases develop between the ages of 5 and 7 [39]. Chordoma affects more men than women, and it can strike anybody between the ages of 29 and 79 [15]. A lytic destructive lesion with varying sclerosis, a soft tissue

mass, and maybe amorphous calcification can be seen on radiographs. Specifically, the sacrum, where there is typically a big mass of soft tissue. The tumor showed substantial soft tissue mass and lytic bone destruction without any internal calcification, and its size varied from 2.8 to 19.8 cm [39].

The Lymphoma tumor appears hypointense on T1- and T2-weighted imaging, and there is no evidence of an extra-bony lesion. [40]. A lymphoma tumor can be anywhere from 0.1 cm and 10 cm in size, and it seldom ever has calcifications. It is strongly defined, spherical, and has a mass impact that distorts adjacent vessels [18]. The frequency of lymphoma is greater in women, and there were a few scattered nonspecific small mediastinal lymph nodes and an ill-defined lesion [41]. A lytic or mixed lytic and sclerotic look, a permeative/moth-eaten appearance, an aggressive-appearing periosteal reaction, and a soft-tissue mass of variable size have all been observed in Lymphoma tumors [42]. Soft tissue mass, selective cortical degeneration, permeative pattern, and sequestrum development are present. T1-weighted imaging reveals low to moderate signal intensity in the tumors in contrast to T2-weighted imaging's high signal intensity. demonstrates a steady and significant improvement in the soft-tissue component [19].

The well-defined, lobulated, solid, heterogeneous mass of Angiosarcoma exhibits lytic lesions [43]. It is extremely unusual and has a mass that is heterogeneously enhancing and osteolytic [44]. A medullary cavity permeation, cortical invasion and transgression, and a single or multicentric, poorly defined lytic lesion are all characteristics of Angiosarcoma [18]. Additionally, there is some cortical injury, periosteal reaction activation, and penetration into soft tissues. T1-weighted MRI scans of the tumors show low signal intensity, but T2-weighted MRI images show moderate to high signal intensity.

Oval, irregular, dumbbell-shaped, striped masses with heterogeneous or homogenous density, as well as well-defined or ill-defined lesions, are features of Hemangiopericytoma [45]. On a T1-weighted MRI, the lesions were iso-intense or hypo-intense, and on a T2-weighted MRI, they were either moderately hyperintense or hyperintense. Both osteolytic and osteoblastic patterns of bone destruction were seen. Additionally, calcification was seen. Very few people have Hemangiopericytoma [46]. The tumor has a honeycomb or reticular pattern with cortical erosion and is lytic or localized sclerotic. Hemangiopericytomas are described as well-defined lesions with an extensive reactive bone formation that can have a "sunburst" or "sunray" pattern, are lytic with coarse trabeculations or striations (giving the appearance of corduroy), and may be expansile [47].

4. RESULTS

Tables outline the taxonomy of tumors along with each one's specific radiographic characteristics. The following fields are included in tables for benign and malignant tumors the name of the tumor the patient's age, the percentage of affected males and females, the location of the tumor the pelvic bone skeleton, the size of the tumor, the zone of transition, whether the tumor is sclerotic or osteolytic, the periosteal reaction, cortical destruction, the matrix mineralization, whether there is a soft tissue component, the shape of the tumor, the borders of the tumor. The malignant tables that have extra fields for the staging of cancer are the AJCC stage and stage subtype.

Table (4.1): Benign Pelvic Bone Tumors Number (1)

Periosteal chondroma	**Chondromyxoid fibroma (CMF)**	**Desmoplastic fibroma**	**Benign fibrous histiocytoma (BFH)**
10-30y, males more	20-70y	20-70y, males more	20-60y, females more
Cartilage cap	Cartilage of bones sacrum and iliac	Pelvic bones iliac and ischium	Pelvic bones iliac, sacrum and ilium
<= 3 cm	2-10 cm	3-16 cm	2-10 cm
narrow	narrow	narrow	narrow
lytic	lytic	lytic	lytic
Sclerotic periosteal reaction	none	none	Juxtacortical
Thin cortical shell, shallow cortical defect	Cortical expansion (breakthrough-thinned)	Thinned cortex and cortical breakthrough	none
Juxtacortical mass	yes	Slowly growing mass	none
A well-circumscribed, lobulated cartilaginous mass, maybe a cup-shaped	Sharply circumscribed radiolucent lesion	Lobulated appearance (mouth-eaten)	Lobulated appearance

Table (4.2): Benign Pelvic Bone Tumors Number (2)

Periosteal chondroma	**Chondromyxoid fibroma (CMF)**	**Desmoplastic fibroma**	**Benign fibrous histiocytoma (BFH)**	**Type name**	**Osteochondroma**	**Eosinophilic Granuloma (EG)**
Well circumscribed	Sharp border (well-defined)	Well-differentiated	Sclerosis of the edges	Age	>20, males more	>12, males more
Popcorn pattern of cartilage	Homogeneous	Soap bubble appearance	Heterogenous	Location	Pelvic bones and cartilage cap	Pelvic bones
Grey	Grayish white lesion	Grayish white lesion	Grey	size	Cartilage cap 1-6 mm, the tumor is < 5cm	small
May have lobulated soft tissue masses at the surface of the bone	May also have small cystic foci or areas of hemorrhage	none	none	Zone of transition	narrow	wide
none	none	none	none	Sclerotic or Osteolytic	lytic	lytic
				Periosteal reaction	none	Chronic periosteal reaction
				Cortical destruction	none	The cortex may be thinned, expanded, or destroyed
				Soft tissue component	none	yes
				Shape	Irregular bony mass	Round or oval

Table (4.3): Osteosarcoma (OS) pelvic bone tumor number (1)

Paget's associated Osteosarcoma				**Post-radiation Osteosarcoma**			
III		IV		III		IV	
IIA	IIB	VA	VB	IIA	IIB	VA	VB
8 cm	8 cm	>8 cm	>8 cm	8 cm	8 cm	>8 cm	>8 cm
>60y				17-68y			
Any pelvic bone				Any pelvic bone			
Wide				Wide			
Mixed, sclerotic, and lytic				lytic			
Aggressive				Aggressive			
Irregular cortical expansion				Bony destruction			
May exist				Exist			
Exist				Exist			
New bone formation (Codman's triangle)				Irradiated area			
Ill-defined, wedge-shaped like a flame with a sharp border				Irregular			

Type name	**Osteochondroma**	**Eosinophilic Granuloma (EG)**
Border	Well defined	Well defined margins
Internal matrix	Pedunculated lesions on the surface of the bone	Punched-out lesions
Color	Bullish grey	Grey
Remarks	The natural bone cortex and the cortex of the lesion are contiguous.	none
Metastasize to	Peripheral chondrosarcoma	none

Table (4.4): Osteosarcoma (OS) pelvic bone tumor number (2)

Paget's associated Osteosarcoma				**Post-radiation Osteosarcoma**				**Type name**	**Low-Grade central Osteosarcoma (LGOS)**			
III		IV		III		IV		AJCC stage	I		II	
IIA	IIB	VA	VB	IIA	IIB	VA	VB	Stage subtype	A	B	IA	IB
Heterogenous								size	3.3-8 cm	8-14 cm	3.3-8 cm	8-14 cm
Grey				Grey				Age	15-40 y			
More in males History of Paget's disease Common among North European-Anglo-Saxon, New Zealanders, and Australian people				History of radiation therapy				Location	Ilium, ischium, pubis, and sacrum			
								Zone of transition	Wide			
				Lung and other bones				Sclerotic or Osteolytic	Mixed, sclerotic, and lytic			
								Periosteal reaction	Not aggressive		Aggressive	
								Cortical destruction	Irregular cortical expansion			
								Matrix mineralization	May exist			
								Soft tissue component	Exist			
								Shape				
								Border	Well-defined			

Table (4.5): Chondrosarcoma (CHS) pelvic bone tumor

Central Chondrosarcoma				**Periosteal chondrosarcoma**							
III		IV		I		II		III		IV	
IIA	IIB	VA	VB	A	B	IA	IB	IIA	IIB	VA	VB
4-8 cm	8 cm	>8 cm	>8 cm	3-8 cm	8-14 cm	3-8 cm	8-14 cm	3-8 cm	8-14 cm	>8 cm	>8 cm
30-60y, males more				20-40y							
Wide				Wide							
Well-defined lytic				Well-defined lytic							
Very aggressive				Aggressive				Very aggressive			
Cortical thickening				Either eroded or often thickened by the tumor, but never destroyed							
Popcorn mineralization				Chondral-type matrix mineralization							
Irregular border				Irregular border							
Greyish-white				Greyish-white							
Lung and other bone										Lung and other bone	
Has tri-radiate cartilage				A Codman’s triangle maybe seen							

Type name	**Low-Grade central Osteosarcoma (LGOS)**			
AJCC stage	I		II	
Stage subtype	A	B	IA	IB
Internal matrix				
Color	Grey			
Remarks				
Metastasize to				

Table (4.6): Chondrosarcoma (CHS) pelvic bone tumor (more)

Secondary chondrosarcoma					
I		II		III	
A	B	IA	IB	IIA	IIB
8 cm	8 cm	8 cm	8 cm	>8 cm	>8 cm
20-60y					
Wide					
lytic					
Aggressive		Aggressive		Very aggressive	
Cortical destruction or erosion					
Punctate area					
Lobular growth pattern					
Irregular					
Greyish-white					
Originate from a pre-existing lesion Patients with Enchondroma, Ollier's disease, and Maffucci's syndrome could suffer The cartilage cap has a 1.5–12 cm thickening (mean 5.5-6 cm)					

Type name	**Mesenchymal chondrosarcoma**							
AJCC stage	III		V		I		II	
Stage subtype	IIA	IIB	VA	VB	A	B	IA	IB
Size	8 cm		>8 cm		4-8 cm	8 cm	4-8 cm	8 cm
Age	20-40y							
Zone of transition	Wide							
Sclerotic or Osteolytic	Ill-defined lyric							
Periosteal reaction	Very aggressive				Aggressive			
Cortical destruction	Bony destruction				Cortical remodeling			
Matrix mineralization	Popcorn calcification				Ambiguous matrix calcification			
Shape and border	Mouth-eaten permeative bone destruction				Lobulated with an irregular border			
color	Greyish-white							
Metastasize to	Lung and other bones							
Remarks								

Table (4.7): More malignant pelvic bone tumor number (1)

Non-Hodgkin's lymphoma	**Angiosarcoma**			**Musculoskeletal hemangiopericytoma**			
	II	IV		I		II	
	IIA	VA	VB	A	B	IA	IB
4-14 cm	10 cm	any	any	8 cm	8 cm	8 cm	8 cm
2-88y, males more	10-80y, males more			12-90y			
Ilium, ischium, sacrum and coccyx	Pelvis			Pelvis			
Wide	Wide			Wide			
Lytic	Lytic and sclerotic			Lytic			
Aggressive	Very aggressive			None			
Cortical destruction	Focal destruction of the cortex			Cortical erosion			
None	None			Nona			
Exist	a significant mass of soft tissue that is mostly anterior and extends to the cartilage level			None			

Type name	**Dedifferentiated chondrosarcoma**			
AJCC stage	III		IV	
Stage subtype	IIA	IIB	VA	VB
Size	8 cm	8 cm	>8 cm	>8 cm
Age	50-60y			
Zone of transition	Wide			
Sclerotic or Osteolytic	lytic			
Periosteal reaction	none			
Cortical destruction	none			
Matrix mineralization				
Shape	A solid and benign appearance			
Border	Irregular			
Color	Greyish-white			
Remarks	High-grade non-cartilaginous sarcoma			
Metastasize to				Lung and other bones

Table (4.8): More malignant pelvic bone tumor number (3)

Angiosarcoma	**Musculoskeletal hemangiopericytoma**
Multiple lytic lesions	A honeycomb or reticular pattern
Infiltrative margins	Well-marginated areas of lysis, with or without a sclerotic rim
Grey	Grey
Bones	
originating from the low-grade tumor that is forming cartilage. A malignant vascular tumor. It starts anywhere and metastasizes to bones.	The malignancy invaded soft tissue and destroyed the cortex.

Type name	**Ewing's sarcoma**				**Conventional chordomas**
AJCC stage	III		IV		
Stage subtype	IIA	IIB	VA	VB	
Size	8 cm	8 cm	>8 cm	>8 cm	2-5 cm
Age	5-25y, males more				30-70y, males more
Location	Ilium, ischium, pubic and iliac				Sacrum and coccyx
Zone of transition	Wide				Wide
Sclerotic or Osteolytic	Ill-defined, sclerotic				Osteolytic-lytic
Periosteal reaction	Aggressive (onion skin, Codman'' triangle, sunburst)				Aggressive
Cortical destruction	Cortical violative, splitting and thickening of the cortex				Bony destruction
Matrix mineralization	None				Focal calcification
Soft tissue component	Large soft tissue component				Exist

Type name	Ewing's sarcoma	Conventional chordomas	Non-Hodgkin's lymphoma
Shape	Moth-eaten destructive permeative lucent lesions	Sacrum may appear enlarged	Permeative or mouth-eaten pattern, and subtle mottled appearance
Border	Irregular-shape	Marginal sclerosis	Irregular
Color	Grey to white	Grey	Grey
Metastasize to	Lung		
Remarks	Affects white more than blacks and Asians. Having its origin in the medullary cavity and having invaded the Haversian system	Characterized by the absence of cartilaginous	

5. DISCUSSION

Patients with malignancies in the pelvic bone are often older patients with bigger tumors than those in the extremities. The majority of tumors in the proximal femur are benign (fibrous dysplasia, solitary bone cyst, and osteoid osteoma), but the majority of tumors in the pelvis are malignant (metastases, myeloma, chondrosarcoma, Ewing-, osteo-, and MFH/fibrosarcoma). Sarcomas without tumor-specific symptoms are often soft tissue lumps in the thigh of older patients.

Bone and soft tissue sarcomas are rare malignant tumors that account for about 1.2% of all malignancies. It has been determined that primary bone tumors make up less than 0.2% of all cancers. Additionally, it is demonstrated that among original non-hematologic malignant bone tumors Osteosarcoma (68%), Chondrosarcoma (12%), and Ewing sarcoma (4%) occur more often. Pelvic bone cancers are quite uncommon. lytic lesions with cortical breakthrough, growth into adjacent soft tissues, and a variety of periosteal reactions are seen in the majority of malignant pelvic bone tumors. The majority of cancers appear grey on CT images and are highly intense on T1 MRI scans while being less intense on T2 scans. Age, location, and bone lesion form are the most crucial diagnostic indicators for bone cancers. Men are often more affected by tumors than women. In contrast to other research, this study provides a detailed breakdown of the distribution of the majority of pelvic bone tumor radiographic features.

It is evident that individuals with Paget's associated osteosarcoma have a history of the condition and that they tend to be North European-Anglo-Saxon, New Zealanders, and Australians. A pre-existing lesion or individuals with Enchondroma,

Ollier's disease, or Maffucci's syndrome are the causes of Secondary Chondrosarcoma. It has a 1.5–12 cm thick cartilage cap (mean 5.5-6 cm). Whites are more likely than blacks and Asians to get Ewing's sarcoma. Therefore, a low-grade tumor that forms cartilage is where Angiosarcoma develops.

6. CONCLUSION

In this article, we list and show typical benign and malignant primary tumors that affect the skeletal pelvis as well as their radiographic features. The first step in identifying the tumor type is determining where the tumor is in relation to the pelvic bones. The second major component is the patient's age. The radiographic features of the tumor can then be defined with the use of CT and MRI imaging. However, the definitive diagnosis is determined with the aid of the clinical history and biopsy.

It was found that there aren't many databases specifically devoted to these tumors. This served as the impetus for creating a database with all the radiographic features of tumors. As a result, the study's main objective is to review the research on pelvic bone tumors that have been done between 2018 and 2022. Another thing to undertake is to compile previous research on pelvic bone tumors using a taxonomy. This study employed a specific research methodology that the researchers had already approved. As a result, we were able to create tables that display a tumor's radiographic features and its malignant or benign status. In these tables, the tumor's stage is also indicated if it is malignant. This study facilitates the work of other researchers and can be used as a starting point.

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