Case Report

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Long bone metastases of renal cell carcinoma imaging features: case report and literature review

https://doi.org/10.1515/oncologie-2023-0080
Received February 27, 2023; accepted May 14, 2023; published online June 14, 2023

Abstract

Objectives: This article analyzed the imaging features of 18 long bone metastasis (LBM) of renal cell carcinoma (RCC) confirmed by pathology and reviewed the available literature.

Case presentation: Patients who underwent radiographic examinations at our hospital between January 2015 and December 2021 with pathology-confirmed bone metastases were evaluated. The clinical and radiographs and CT, and MR images features of the patients were analyzed. Eighteen patients with pathology-confirmed LBM from RCC were collected. All the patients had X-ray examinations, 15 had computed tomography (CT), 13 had magnetic resonance (MR) imaging, and six had MR enhancement. The clinical and imaging features of the lesions were analyzed, including morphological and signal intensity characteristics. Ten patients were found with metastases after nephrectomy, and eight patients were admitted to the hospital with skeletal-related events (SREs). Eighteen cases originated from clear cell RCC. Fourteen lesions were located in the epiphysis and four in the diaphysis. The height-to-width ratio of the lesions ranged from 1.11 to 3.41 (mean, 1.84). All lesions showed osteolytic destruction, with 16 lesions showing expansile destruction. Seven lesions demonstrated soap bubble hyperintensity and hypointense separation on T2-weighted images. Six lesions demonstrated a flow-void sign, and six showed marked marginal enhancement.

Conclusions: The LBM of RCC mainly occurred in the proximal epiphysis and tended to spread along the long bone axis with expansile osteolytic destruction. In some cases, soap bubble hyperintensity, hypointense separation, and the flow-void sign were seen.

Keywords: case report; long bone; metastasis; MR; renal cell carcinoma

Introduction

Renal cell carcinoma (RCC) is a clinically common malignant tumor worldwide. The major histologic subtype of RCC is clear cell RCC (ccRCC) [1–3]. ccRCC is prone to early hematogenous metastasis. Bone (20–40 %) is the second most common metastatic site of RCC after the lung (70 %) [2, 4, 5]. Although bone metastasis is far more prevalent than primary bone malignancy, solitary metastasis that occurs in the extremities is relatively rare. Solitary long bone metastasis (LBM) may accompany an occult primary renal tumor, or it may be delayed metastasis from a previously treated lesion [6]. Most of these patients are admitted to the hospital with bone pain and a pathological fracture as the first symptom. Therefore, imaging examination is of great significance for the early detection and diagnosis of LBM of RCC [5–9].

X-ray, computed tomography (CT), and magnetic resonance imaging (MRI) are the most common examination methods. Due to excellent soft tissue resolution, MRI is the preferred imaging modality of choice for assessing metastatic spread in the marrow cavity, an extension of the tumor from the marrow cavity, and the involvement of surrounding structures [8]. The sites of bone metastases from RCC have been reported, including the spine, ilium, skull, clavicle, rib, humerus, femur, tibia, and fibula [6, 10–15]. Fewer than 10 cases of solitary LBM were reported between 2000 and 2019 [5, 6, 13, 14]. The X-ray and CT images showed that the RCC metastases mostly had osteolytic destruction with expansile change, no periosteal reaction, and were soft-tissue masses [5, 12–15]. The MR images demonstrated hypervascularity, slight hypointensity or isointensity of the masses on T1-weighted images (T1WI), and hyperintensity or mixed signals on T2-weighted images.
Shi and Zhang: Long bone metastases of renal cell carcinoma imaging features

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have summarized the MR imaging features of a series of

vessels of bone metastases from RCC [6, 7], but no articles

The MR imaging of LBM of RCC might show certain

characteristics. Two articles specifically reported the flow

vessels of bone metastases from RCC [6, 7], but no articles

have summarized the MR imaging features of a series of

solitary LBMs. This article retrospectively analyzed the

imaging features of 18 LBMs of RCC confirmed by pathology

and reviewed the available literature, aiming to explore the

imaging features and improve the accuracy of diagnosis.

Materials and methods

Patients

Patients who underwent radiographic examinations at our hospital

between January 2015 and December 2021 with suspected bone metas-
tases were evaluated. The inclusion criteria were: (1) long bone lesions
pathologically confirmed as bone metastases of ccRCC and (2) patients
with bone metastasis who underwent imaging examinations before the
initiation of cancer-directed therapy. The clinical and imaging features
of the patients were analyzed.

Imaging protocol

X-ray scanning was performed on a SIEMENS Ysio DR X-ray scanner. CT
images were obtained using a multidetector CT scanner (Philips Bril-
liance, Philips Brilliance iCT, and Siemens Healthineers), with 64–256
detector rows. The sagittal and coronal images were reconstructed to
obtain the axial images. The scanning parameters were 120 kV, automatic
milliamper setting (range 80–320 mA), and a pitch of 1 and 5 mm
contiguous section thickness. Imaging was followed by the use of bone
tissue (window width (WW): 1,600–2,500 HU, window level (WL): 500–
800 HU) and soft tissue (WW: 300–500 HU, WL: 45–60 HU) algorithms.

MR imaging was performed with a 3.0 T magnet (Siemens Medical
Solutions, Germany). The imaging parameters were slightly different
depending on the imaging site. The pre-contrast scanning sequences
were axial T1WI (repetition time (TR)=500–520 ms, echo time (TE)=11–
15 ms, 5 mm thickness); axial, coronal fat suppression T2WI (TR=3,500–
4,000 ms, TE=81–138 ms, 5 mm thickness); and sagittal T2WI (TR=3,500–
4,000 ms, TE=106–131 ms, 5 mm thickness). Enhanced scanning was
performed by an intravenous injection of gadopentetate dimeglumine
(Gd-DTPA, 3 mL/s, 0.1 mmol/kg), and the sequences also included axial,
sagittal, and coronal enhanced T1WI scans (TR=160–185 ms, TE=1–2 ms,
5 mm thickness).

Image evaluation

Two experienced radiologists (with three and 10 years of work experi-
ence, respectively, in musculoskeletal imaging) separately reviewed all
the images on a picture archiving and communication system. Any
discordance was resolved by consensus. The morphological features of
the lesions were evaluated on the radiographs and CT images, including
the location (proximal epiphysis, diaphysis, and distal epiphysis), size
(maximum height in the sagittal position and maximum width on axial
view), height-to-width ratio (maximum height/maximum width), mar-
gins (well-defined or ill-defined), bone destruction (expansile or non-
expansile), cortical bone (interruption or continuity), periosteal reac-
tion, and soft-tissue mass.

The lesion signal intensity characteristics on MR images were
analyzed, including the signal intensity of each sequence (lesion signal
intensity lower than the signal intensity of muscle was described as
hypointense; the same as the signal intensity of muscle, as isointense;
greater than the signal intensity of muscle but less than the signal in-
tensity of fat, as hyperintense), the signal uniformity on T2WI (uniform-
ity or uneven), soap bubble sign (heterogeneous hyperintensity on
T2WI), separation (curvilinear area of hypointensity in the mass on
T2WI), flow-void sign (multiple dot-like or tubular structures with low
signal intensity located within or around the lesion that probably cor-
responded to vessels) [6], enhancement amplitude (unenhanced, slightly
enhanced, or markedly enhanced compared with surrounding normal
enhancing muscle and vessels), and uniformity.

Case illustration

Clinical features

Eighteen patients (15 males, three females; age range, 48–74
years; average age, 63.8 ± 5.3 years) were included in this study. All patients had X-ray examinations, 15 had CT, 13 had
MR imaging, and six had MR enhancement.

Metastases were found after nephrectomy in 10 pa-
tients, and the median time interval between nephrectomy
and the diagnosis of metastasis was one year (range,
0.5 months–10 years). The other eight patients were
admitted to the hospital with limb pain as the first symptom,
and five patients progressed to pathological fractures, which
were then diagnosed as having an RCC source. All of the
cCRCCs were pathologically confirmed as well.

The mean follow-up period for 18 patients was
13.5 months (3–24 months). Nine patients underwent radio-
therapy and chemotherapy, and another nine underwent
surgery, followed by chemotherapy. During the follow-up
period, 11 patients had multiple metastases in the axial
skeleton, two had brain metastases, two had lung metastas-
es, one had a right pubic metastasis, one had lung and
adrenal metastases, and one had no new metastasis.

Table 1 summarizes the clinical information, including
patient age, sex, the location of the tumor, clinical presenta-
tion, and laboratory parameters, as well as the clinical follow-up.

Morphological features

Fourteen lesions were located in the extremities, including
the proximal femur (six cases), proximal humerus (four

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Morphological features

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Table 1: Clinical findings in 18 patients with osseous metastases of ccRCC.

<table>
<thead>
<tr>
<th>Patient no./sex</th>
<th>Tumor location</th>
<th>PT, s</th>
<th>PTA, %</th>
<th>ALB/GLO (1.2–2.4)</th>
<th>PLT, (10^3/L)</th>
<th>FIB, g/L</th>
<th>Follow-up, month</th>
<th>Interval between nephrectomy and osseous metastasis, month</th>
<th>Other metastatic lesions</th>
<th>Main symptom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/M/62</td>
<td>Diaphysis</td>
<td>13.6</td>
<td>94</td>
<td>1.18</td>
<td>330</td>
<td>4.71</td>
<td>7</td>
<td>36</td>
<td>Axial skeleton</td>
<td>Fracture</td>
</tr>
<tr>
<td>2/M/62</td>
<td>Proximal femur</td>
<td>13.6</td>
<td>97</td>
<td>1.03</td>
<td>365</td>
<td>2.74</td>
<td>12</td>
<td>1</td>
<td>Axial skeleton</td>
<td>Pain</td>
</tr>
<tr>
<td>3/M/49</td>
<td>Proximal femur</td>
<td>13.8</td>
<td>93</td>
<td>1.75</td>
<td>203</td>
<td>2.67</td>
<td>18</td>
<td>0</td>
<td>Axial skeleton</td>
<td>Pain</td>
</tr>
<tr>
<td>4/M/63</td>
<td>Proximal humerus</td>
<td>13.6</td>
<td>95</td>
<td>1.42</td>
<td>157</td>
<td>2.31</td>
<td>6</td>
<td>0.5</td>
<td>Axial skeleton</td>
<td>Fracture</td>
</tr>
<tr>
<td>5/M/74</td>
<td>Proximal femur</td>
<td>13.1</td>
<td>101.1</td>
<td>1.32</td>
<td>216</td>
<td>3.19</td>
<td>24</td>
<td>120</td>
<td>No</td>
<td>Pain</td>
</tr>
<tr>
<td>6/F/64</td>
<td>Proximal radius</td>
<td>14</td>
<td>88</td>
<td>1.47</td>
<td>256</td>
<td>2.85</td>
<td>16</td>
<td>60</td>
<td>Brain</td>
<td>Fracture</td>
</tr>
<tr>
<td>7/M/64</td>
<td>Distal femur</td>
<td>14</td>
<td>89</td>
<td>1.38</td>
<td>272</td>
<td>4.11</td>
<td>20</td>
<td>36</td>
<td>Lung</td>
<td>Pain</td>
</tr>
<tr>
<td>8/M/64</td>
<td>Proximal femur</td>
<td>12.6</td>
<td>114.0</td>
<td>1.38</td>
<td>268</td>
<td>2.86</td>
<td>10</td>
<td>0</td>
<td>Axial skeleton</td>
<td>Pain</td>
</tr>
<tr>
<td>9/M/60</td>
<td>Diaphysis</td>
<td>12.1</td>
<td>126</td>
<td>1.46</td>
<td>278</td>
<td>7.3</td>
<td>15</td>
<td>0</td>
<td>Axial skeleton</td>
<td>Pain</td>
</tr>
<tr>
<td>10/M/63</td>
<td>Proximal humerus</td>
<td>12.6</td>
<td>109</td>
<td>1.38</td>
<td>259</td>
<td>5.75</td>
<td>10</td>
<td>0</td>
<td>Axial skeleton</td>
<td>Fracture</td>
</tr>
<tr>
<td>11/F/61</td>
<td>Proximal humerus</td>
<td>14.8</td>
<td>79</td>
<td>1.79</td>
<td>198</td>
<td>2.38</td>
<td>12</td>
<td>1.5</td>
<td>Axial skeleton</td>
<td>Pain</td>
</tr>
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<td>94</td>
<td>1.65</td>
<td>332</td>
<td>4.71</td>
<td>3</td>
<td>0</td>
<td>Adrenal gland, lung</td>
<td>Fracture</td>
</tr>
<tr>
<td>13/M/64</td>
<td>Distal femur</td>
<td>13.8</td>
<td>102</td>
<td>1.54</td>
<td>284</td>
<td>274</td>
<td>10</td>
<td>0</td>
<td>Axial skeleton</td>
<td>Pain</td>
</tr>
<tr>
<td>14/M/60</td>
<td>Proximal radius</td>
<td>13.4</td>
<td>98</td>
<td>1.48</td>
<td>299</td>
<td>3.54</td>
<td>9</td>
<td>12</td>
<td>Lung</td>
<td>Fracture</td>
</tr>
<tr>
<td>15/M/58</td>
<td>Diaphysis</td>
<td>13.4</td>
<td>103</td>
<td>1.46</td>
<td>304</td>
<td>3.12</td>
<td>20</td>
<td>0</td>
<td>Axial skeleton</td>
<td>Pain</td>
</tr>
<tr>
<td>16/M/70</td>
<td>Proximal humerus</td>
<td>13.6</td>
<td>97</td>
<td>1.38</td>
<td>314</td>
<td>2.74</td>
<td>6</td>
<td>36</td>
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<td>18</td>
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<td>Pubis</td>
<td>Pain</td>
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<tr>
<td>18/M/70</td>
<td>Proximal femur</td>
<td>12.7</td>
<td>94</td>
<td>1.64</td>
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<td>2.13</td>
<td>12</td>
<td>36</td>
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<td>Fracture</td>
</tr>
</tbody>
</table>

PT, plasma prothrombin time; normal range 11.5–14.5 s. PTA, plasma prothrombin time activity; normal range 75–125 %. ALB, albumin; GLO, globulin; normal range 1.2–2.4 g/L. PLT, platelet count; normal range 125–350 × 10^9/L. FIB, fibrinogen; normal range 2–4 g/L.

MRI characteristics

The MR characteristics of 13 lesions are shown in Table 3. Eight lesions demonstrated soft tissue masses with a lobular shape, and the other four lesions were without a soft tissue mass. Eleven cases demonstrated slight hypointensity or isointensity on T1WI and mixed isointensity and hyperintensity on T2WI. In these cases, seven lesions demonstrated soap bubble signs and hypointense separation on T2WI (Figure 2). Two cases demonstrated homogeneous isointense signals on T1WI and slightly hyperintense signals on T2WI. The flow-void sign was observed in six lesions (Figure 1). Seven patients underwent enhanced scanning, and the lesions demonstrated marked marginal enhancement (enhanced similar to normal vessels) with no enhancement in the center (Figure 3).
Bone scintigraphy

Three patients underwent bone scintigraphy and demonstrated increased focal uptake in the metastatic margins, while there was no significant local uptake in the central regions. See supplementary Table 4 for the summary of the latest publications on bone metastases from ccRCC.

Discussion

Bone metastasis of RCC is more common in older males and occurs in the axial skeleton and proximal appendicular skeleton. When it occurs in the appendicular skeleton, it is most common in the femur and humerus [8]. Stomeo et al. found that infra-diaphragmatic neoplasms are easily
metastasized to the pelvis in a retrograde manner through the valveless Batson’s vertebral venous plexus [16]. Our study results showed that 15 (15/18, 83.3 %) patients were male, with an average age of 63.1 years. This result may be explained by the potential selection bias of retrospective studies, but it also indicated that the bone metastases of RCC were more likely to occur in older men. A study by Choi also reported that 14 (14/16, 87.5 %) patients with RCC bone metastases were older men [6]. In this study, 10 (10/14, 71.4 %) lesions were located in the proximal epiphysis of the appendicular skeleton, with six (6/10, 60 %) lesions in the femur and four (4/10, 40 %) in the humerus, consistent with a previous report [8, 16]. Six patients still had only one bony lesion during the follow-up period. Zekri et al. reported similar results in which 14 (14/31, 45 %) patients had a solitary metastatic lesion from RCC at the time of diagnosis and 8 (8/31, 26 %) patients continued to have only one lesion during the study period [9]. The reason might be that solitary bone metastases of RCC affect the appendicular skeleton more frequently than other solid tumors [9]. Choi et al. reported that RCC frequently manifested first as osseous (often solitary) metastasis from a clinically occult primary tumor [6].

Eight patients were admitted to the hospital due to skeletal-related events (SREs), including four who experienced pathological fractures in long bones. The report by Zekri also demonstrated that pain and pathological fractures were the most frequent SREs of bone metastases, with incidences of 81 and 42 %, respectively, and considered that RCC was a common cause of pathological fractures in long bones [9]. By further comparing the incidence of SREs in metastatic bone disease from RCC and breast cancer, their research demonstrated that the incidence of hypercalcemia was a little higher than that in the latter, but the incidence of pathological long bone fractures and spinal cord compression was similar.

Table 4: Summary of the latest publications on bone metastases from ccRCC.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Primary carcinoma</th>
<th>Number of cases</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zekri [9]</td>
<td>2001</td>
<td>RCC</td>
<td>103</td>
<td>It would therefore be appropriate to evaluate the effectiveness of bisphosphonate treatment for reducing skeletal morbidity in advanced renal cell cancer with bone metastases.</td>
</tr>
<tr>
<td>Setlik [13]</td>
<td>2009</td>
<td>RCC</td>
<td>1</td>
<td>Renal cell carcinoma manifesting as a solitary bone metastasis</td>
</tr>
<tr>
<td>Xie [29]</td>
<td>2012</td>
<td>RCC, prostate cancer, lung cancer, breast cancer, melanoma</td>
<td></td>
<td>Unique angiogenic and vasculogenic properties of renal cell carcinoma in a xenograft model of bone metastasis are associated with high levels of vegf-a and decreased ang-1 expression</td>
</tr>
<tr>
<td>Pazionis</td>
<td>2014</td>
<td>RCC, thyroid carcinoma</td>
<td>53</td>
<td>Preoperative embolization probably reduces estimated blood loss, particularly for large tumors and during open femoral procedures.</td>
</tr>
<tr>
<td>Stomeo [16]</td>
<td>2015</td>
<td></td>
<td></td>
<td>The prognosis of the patients with acrometastases is poor. Special renal cell carcinoma; if treated with radical surgical resection and nephrectomy a better outcome and survival rate shall be expected.</td>
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In this study, only five patients experienced elevated FIB, of which three (3/5) were accompanied by pathological fractures. The production of plasma fibrinogen typically increases during cancer progression, systemic inflammation, trauma, surgery, and vascular thromboembolism [18]. Xie et al. found a positive correlation between pre-treatment plasma fibrinogen levels and bone metastasis burden in prostate cancer patients [19]. The imaging findings of skeletal lesions, such as dilated metastases and hemorrhagic lesions, especially in patients with bone metastases of unknown origin, can provide valuable clues to primary renal cell carcinoma or thyroid cancer [20]. Early diagnosis and timely treatment can reduce or prevent SREs, alleviate pain, and improve the quality of life, such as preventing impending pathological fractures by assigning scores to the location, nature, size, and pain of bone metastases [20].
The average height-to-width ratio of long bone metastases of RCC was 1.84. The minimum was 1.11, which was greater than 1, indicating that long bone metastases tended to spread along the long bone axis. Toomayan et al. reported that this might be related to the high-resistance natural barriers in the extremities, including cortical bone, articular cartilage, major fibrous septa, tendinous origins, and muscle insertions [21]. Bone metastases of RCC often appeared with the characteristic of typically expansive ostolytic destruction [3]. In this study, only two lesions, which were located in the marrow cavity and had relatively smaller maximum widths of only 23 mm, did not demonstrate expansive bone destruction, so the characteristics of expansive growth were not demonstrated. In the early period, the long bone metastases are small, often located in the marrow cavity, and most are not detected on the X-ray. CT only demonstrates inhomogeneous marrow cavity density and can demonstrate bone marrow metastases before bone destruction occurs [8]. In this group, no lesion demonstrated normal X-rays or abnormal marrow cavity density in CT, which might be related to the larger lesions confirmed by pathological surgical biopsy.

MRI is highly sensitive for detecting bone metastasis as it has the capability to demonstrate intramedullary metastasis, which usually demonstrates T1 hypointensity and T2 hyperintensity [5, 8]. In these cases, three lesions were confined to the marrow cavity and demonstrated mixed signals on T2WI, which were different from the above. The reason could be that the maximum height of the lesion was relatively long, and the lesion could be biopsied by surgical pathology. ccRCC is the most common histologic subtype and accounts for 70% of RCC. It may exhibit a variety of histoarchitectural patterns, including solid, alveolar, and acinar forms. In addition, ccRCC is highly vascular and can develop a network of small thin-walled sinusoid-like blood vessels. Previous studies reported that when the mass was large, the central areas of hemorrhage, necrosis, and cystic changes resulted in a typically heterogeneous appearance on MR images [3, 22]. In these cases, 10 lesions had heterogeneous hyperintensity on T2WI and fat-suppressed T2WI, and seven lesions demonstrated soap bubble or honeycomb hyperintensity on T2WI surrounded by curvilinear hypointense separation. Chen mentioned similar multiple fluid-fluid levels in gastric cancer bone metastases, which were considered to be due to hemorrhage in the tumors and may be found in any form of highly vascular bone neoplasm [23]. However, the cases in our study only demonstrated soap bubble hyperintensity, which may imply the hemorrhage in the tumor. The linear hypointense separation in the tumor was not a bony component and might have been a network of small thin-walled sinusoid-like blood vessels or a fibrous separation similar to giant cell tumors [6, 24]. Soap bubble hyperintensity and linear hypointense separation could be helpful in diagnosing long bone metastases of ccRCC.

In this study, in addition to the above, six lesions appeared as flow voids with a ccRCC pathological type. Choi reported a similar sign and named it the flow-void sign [6]. Setlik also reported a case of ccRCC bone metastases with prominent flow voids in the lesion and thought it might be related to the unique angiogenesis of ccRCC and its metastasis [13]. Xie et al. developed a xenograft model to study the unique angiogenic characteristics of bone metastases of RCC [25]. Compared to lung cancer, breast cancer, RCC, prostate cancer, and melanoma, ccRCC itself is more likely to promote the formation of tumor blood vessels due to its significant expression of vascular endothelial growth factor. The number, diameter, and density of blood vessels in the lesions and metastases are several times higher than those of other tumors [25]. Therefore, ccRCC and its metastases are hypervascular and prone to exhibiting flow void signs [26]. Pang reported a case of skull metastases of ccRCC with an initial diagnosis of hemangioma [11]. Therefore, improving the understanding of the flow-void sign is helpful for the diagnosis and clinical treatment of bone metastasis of ccRCC, including anti-angiogenic therapies and immunotherapy [6, 27]. The presence of the flow-void sign on MRI should raise the suspicion of RCC bone metastasis. When considering biopsy or other interventions for lesions, the flow-void sign should also be used as an indicator of vascular overgrowth [7]. Paziolis performed a case-control study and found that preoperative embolization reduced estimated blood loss and operative time, particularly for large tumors and during open femoral procedures [28]. Recent studies showed that besides using tumor diameter as a criterion for evaluating treatment effectiveness, measuring the contrast enhancement of ccRCC may be a more relevant tool for providing information on anti-angiogenic treatment responses [29]. Hellbach et al. found that the quantitative analysis of iodine content in ccRCC metastatic lesions based on dual-energy CT could significantly improve the sensitivity and repeatability of anti-angiogenic treatment effects [29].

Besides solitary plasmacytoma, solitary malignant tumors can also represent osteosarcoma, chondrosarcoma, and bone metastasis from lung cancer in the long bone, which should be differentiated from a solitary LBM of RCC. Long bone solitary plasmacytoma has been described as single punched-out ostolytic lesions, diffuse osteopenia, fractures, and rarely, osteosclerosis. The lesion demonstrates isointensity on T1WI and hyperintensity on T2WI and might form a “mini-brain” appearance on MR. The mini-brain appearance results from localized bony destruction with the formation of thickened trabeculae, which are arranged in a peripheral radial pattern simulating sulci within the brain [30]. The soft tissue mass is more uniformly enhanced. Bone scans obtained with 99 mTc
have resulted in an underappreciation of the extent of the disease [31]. Primary osteosarcoma in the elderly often occurs in the distal femur and proximal humerus, with mainly characteristic appearances of irregular bone destruction, obvious periosteal reaction, sometimes Codman’s triangle, and a mineralized soft-tissue mass. The sensitivity of MR for identifying tumor bone matrix is poor, and the combination of X-ray and CT is needed to better identify it [31]. Chondrosarcoma is often located in the metaphysis of the long bone, showing expansile destruction, deep endosteal scalloping, and a classical lobular appearance [32]. The pattern of cartilaginous matrix calcification in the mass might be punctate, flocculent, or typical ring-and-arc-type [32]. The lesion demonstrates hypointensity on T1WI and heterogeneous hyperintensity on T2WI with areas of obvious hyperintensity and peripheral and separt enhancement. Sometimes this type of lesion shows rings or amorphous enhanced nodules in the mass [32]. Solitary long bone metastasis from lung cancer could also show expansile changes and little soap bubble hyperintensity on T2WI [33]. Distinctions between the two cases still need further study.

This retrospective study had several limitations. First, it had a small sample size because of the low incidence of LBM. However, in our experience, the expansive osteolytic destruction, soap bubble hyperintensity, the flow-void sign, and other signal characteristics seemed to be typical of LBM of RCC. Second, due to its retrospective analytic nature and pathologically confirmed metastatic lesions, selection bias was inherent as bone metastases may have more complex or atypical manifestations. The patients in this report were a selected population, i.e., patients with clear cell renal carcinoma, and we did not collect other pathological types of renal cell carcinoma. We hope to share our results, which will be helpful in diagnosing this disease, but they must also be verified in further studies using a larger sample size.

LBM of RCC was common in older men and occurred in the proximal femur and humerus. The lesions tended to spread along the long bone axis, with mostly expansile osteolytic destruction, soap bubble or honeycomb hyperintensity, and linear hypointense separation. Also, the flow-void sign might be present in ccRCC metastasis. The above characteristics could be useful for diagnosing LBM of RCC.

Research funding: The author(s) received no specific funding for this study.

Author contributions: Data collation, Z.R., S.D.B.; Literature and clinical research, S.D.B.; Manuscript – original draft, S.D.B.; Manuscript – review and editing, Z.R.; Approval of the submitted version of the manuscript, all authors.

Conflicts of interest: The authors declare that they have no conflicts of interest to report regarding the present study.

Availability of data and materials: The raw data may be made available upon reasonable request from the corresponding author.

Consent for publication: Written informed consent was obtained from the patient for the publication of this case report and accompanying images.

Ethics approval and consent to participate: Informed written consent has been obtained from the patients in this case report to publish this paper. The present study involved human participants, and it was conducted considering ethical responsibilities according to the World Medical Association and the Declaration of Helsinki.

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