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Case Series

Radiology Section

Role of Interventional Radiology in the Management of Vascular Lesions around the Knee Joint: A Series of Four Cases

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ABSTRACT

The soft tissue lesions around the knee range from congenital, traumatic, and vascular to neoplastic in aetiology. The various imaging modalities employed for diagnostic work-up include plain radiographs, ultrasonography, Computed Tomography (CT) scan, and Magnetic Resonance Imaging (MRI). Based on the peculiar imaging findings, the differential diagnosis can be narrowed down; however, the final diagnosis relies on histopathological findings. Some of the highly vascular lesions are arteriovenous malformation, malignant fibrous histiocytoma, haemangiopericytoma, and synovial sarcoma. The abundant neovascularity within these lesions poses a major problem during surgery due to potential blood loss. Presurgical interventional management in the form of endovascular embolisation significantly reduces intraoperative blood loss. Here, four different cases, one of each type, presenting as highly vascular lesions around the knee joint, were successfully managed with endovascular embolisation.

Keywords: Embolisation, Haemangiopericytoma, Malignant fibrous histiocytoma, Synovial sarcoma, Venous malformation

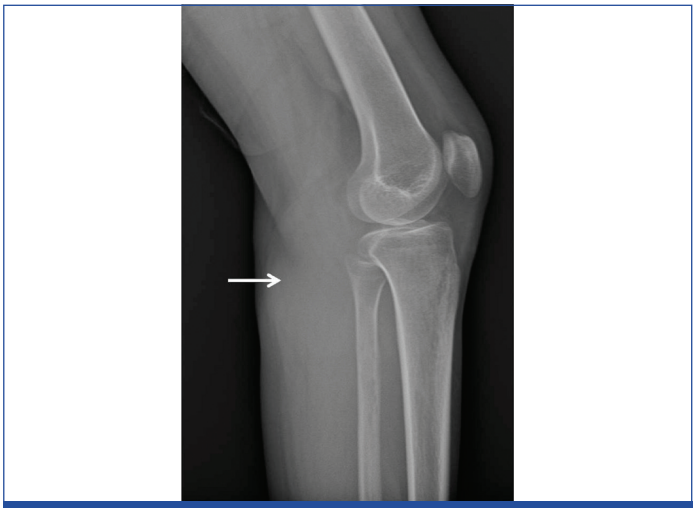
INTRODUCTION

Lesions around the knee can have varying underlying aetiologies. Among them, highly vascular lesions include arteriovenous malformations, haemangioendothelioma, haemangiopericytoma, malignant fibrous histiocytoma, synovial sarcoma, rhabdomyosarcoma, and angiosarcoma. For the treatment of these lesions, surgery has been the standard approach for many years [1]. However, new endovascular techniques have been introduced and have proven to be as effective as open surgery. Recently, their usage has been increasing [1]. Due to the rich neovascularity within these lesions, they are prone to repeated bleeding with mild trauma and during surgery. Therefore, presurgical interventional management in the form of endovascular embolisation significantly reduces perioperative blood loss and patient morbidity [1].

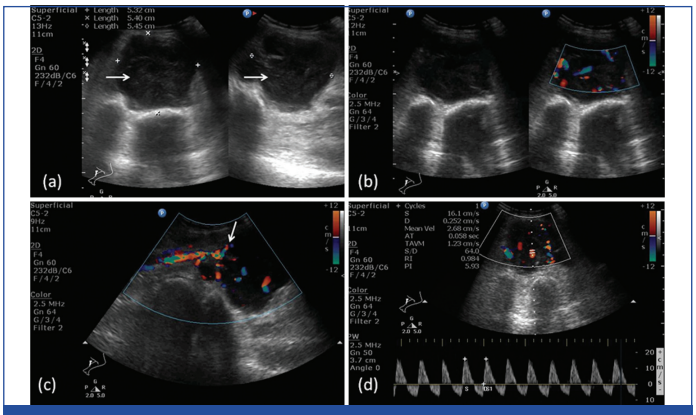
Case 1

Synovial sarcoma: A 22-year-old female patient presented with complaints of painful swelling in the posterior aspect of her left knee for the past eight months. On clinical examination, the swelling measured approximately 5×5 cm and was located on the posterior aspect of the left knee joint, with prominent superficial veins. There was no significant limitation in the movement of the knee joint. Palpation of the swelling revealed warmth and tenderness. The peripheral pulses of the posterior tibial and dorsalis pedis arteries were weak, but there was no neurological deficit.

A lateral view radiograph showed soft tissue swelling [Table/Fig-1]. Ultrasound (US) revealed a predominantly hypoechoic lesion [Table/Fig-2a] with significant vascularity on Doppler [Table/Fig-2b], along with encasement of the popliteal artery [Table/Fig-2c,d]. MRI revealed a heterogeneous signal intensity lesion. On the T1W sequence, it appeared nearly isointense to the adjacent muscles [Table/Fig-3a]. On the T2W sequence, the lesion exhibited a central hyperintense necrotic component [Table/Fig-3b]. There were no haemorrhages or calcifications within the lesion on the gradient echo sequence [Table/Fig-3c]. On T1W fat-suppressed images, the lesion appeared predominantly hyperintense compared to the surrounding muscles

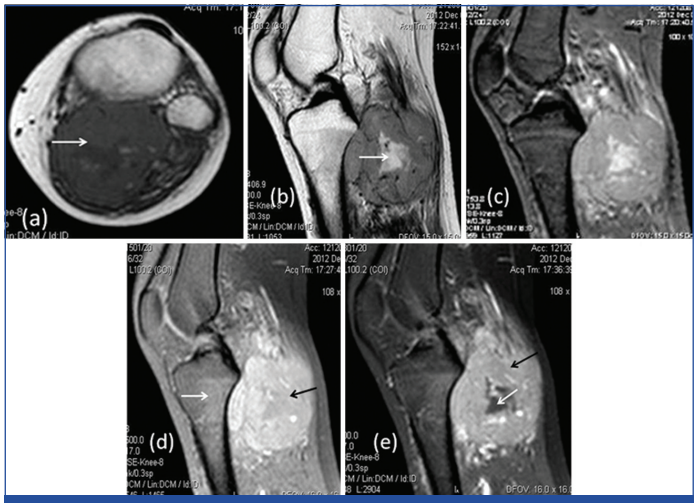


[Table/Fig-1]: Radiograph lateral view of the left knee showing soft tissue radio-opacity on the posterior aspect of knee (white arrow).



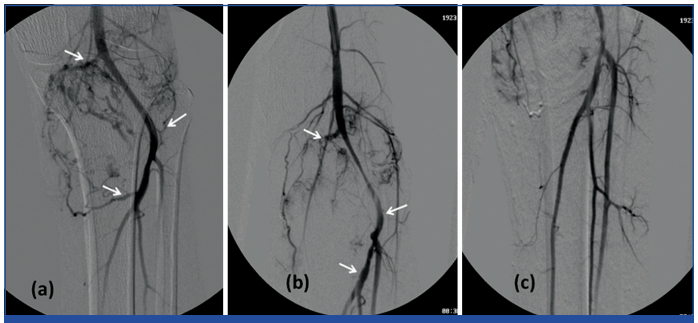
[Table/Fig-2]: a) B mode Ultrasound (US) Transverse section showing the predominantly hypoechoic lesion (white arrows); (b) Colour doppler ultrasound transverse section showing the neovascularity within the lesion; (c) Colour doppler ultrasound longitudinal section showing the encasement of the popliteal artery within the lesion (white arrow); (d) Pulse doppler ultrasound transverse section showing biphasic spectral waveform within the encased popliteal artery, with PSV around 16 cm/s.

[Table/Fig-3d]. Post-gadolinium fat-suppressed T1W sequences [Table/Fig-3e] revealed heterogeneous enhancement of the lesion, with a non enhancing central necrotic component and no obvious intra-articular extension.



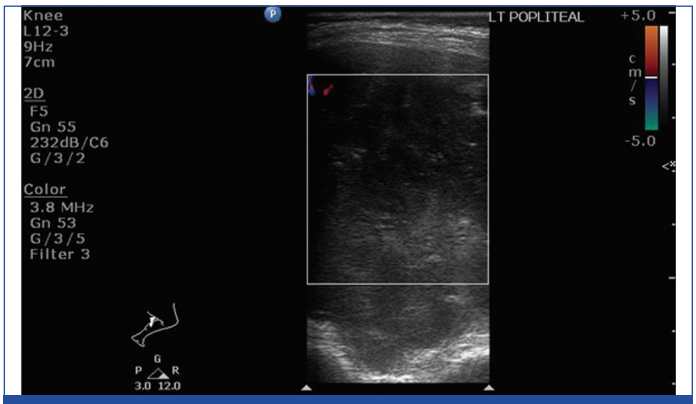
[Table/Fig-3]: a) T1W axial image of the left leg showing irregular, heterogeneous, multilobulated mass (white arrow) with signal intensity nearly similar to the adjacent muscles; b) T2W sagittal image of the left leg showing significant heterogeneity of the lesion with central hyperintense necrotic component (white arrow); c) Gradient Echo/Susceptibility based sagittal image of the left leg showing no obvious foci of blooming within the lesion indicating absence of calcification or haemorrhage; d) T1W Fat Saturated sagittal image of the left leg showing heterogeneous predominantly hyperechoic lesion (black arrow) compared to surrounding muscles. There were altered signal intensity changes noted involving the bone marrow of the metaphysis of tibia which appeared hyperintense (white arrow), however without any obvious cortical breach; e) Post gadolinium T1W fat saturated sagittal image of the left leg showing heterogeneous enhancement of the lesion (black arrow) with non enhancing central necrotic component (white arrow). The lesion was closely abutting the posterior capsule of the knee joint, but there was no obvious intra-articular extension inside the knee joint.

Preoperative embolisation: Retrograde left femoral arterial access was achieved using a 5F vascular sheath. A catheter-guide wire combination was used, and a crossover was performed at the aortic bifurcation to gain access to the left Superficial Femoral Artery (SFA). Angiograms were taken, revealing displacement of the distal popliteal artery and its bifurcation by the lesion. Multiple branches from the popliteal artery, including the anterior and posterior tibial arteries and peroneal artery, were found to supply the lesion [Table/Fig-4a], resulting in multiple sites of abnormal vascular blush. Embolisation was carried out using 100-micron Polyvinyl Alcohol particles (PVA) through a coaxial 2.9F microcatheter via transarterial access. A final check angiogram was performed with the catheter tip in the distal SFA, showing a significant reduction in the abnormal vascular blush [Table/Fig-4b], along with patent and densely filling anterior and posterior tibial as well as peroneal arteries [Table/Fig-4c], indicating the absence of arteriovenous shunting within the lesion. A repeat US examination the following day [Table/Fig-5] revealed a



[Table/Fig-4]: a) Digital subtraction angiography image showing multiple branches from the popliteal artery, anterior and posterior tibial arteries as well as the peroneal artery noted supplying the lesion (white arrows) with resultant multiple sites of abnormal vascular blush; b) Check digital subtraction angiography image showing embolisation of the major supplying arterial branches (white arrows); c) Check digital subtraction angiography image showing embolisation of the major supplying arterial branches supplying the lesion with patent and densely filling anterior and posterior tibial as well as peroneal arteries, due to the absence of the arteriovenous shunting inside the lesion.

significant reduction in the vascularity of the lesion. The lesion was excised with an intraoperative blood loss of approximately 800 mL. The histopathological diagnosis confirmed synovial sarcoma with a predominant mesenchymal element in the form of spindle cells after biopsy. The patient underwent postsurgery radiotherapy and remained asymptomatic during a three-month follow-up period.

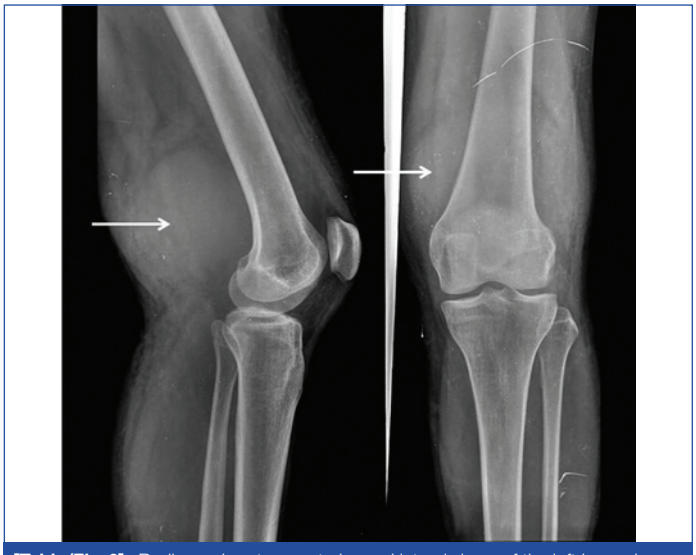


[Table/Fig-5]: Follow-up colour doppler ultrasound transverse section showing significant reduction in the tumour vascularity.

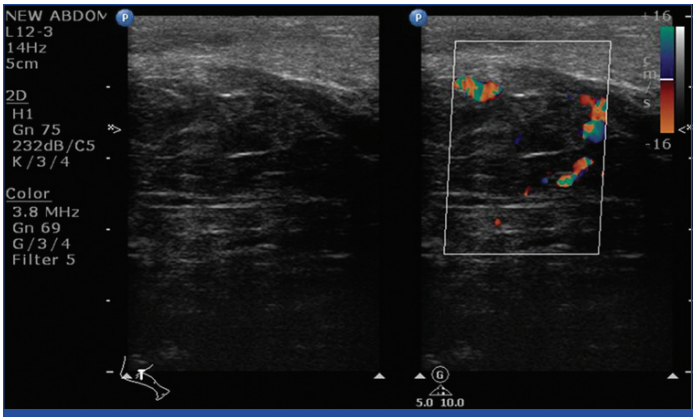
Case 2

Haemangiopericytoma: A 30-year-old female patient presented with complaints of pain and swelling in the left popliteal region for 5-6 months. There was no history of trauma. On clinical examination, the swelling measured approximately 10×5 cm and was located on the posterior aspect of the left knee joint. There was a mild limitation in the movement of the joint, and mild tenderness was present upon palpation. The peripheral pulses of the posterior tibial and dorsalis pedis arteries were normal.

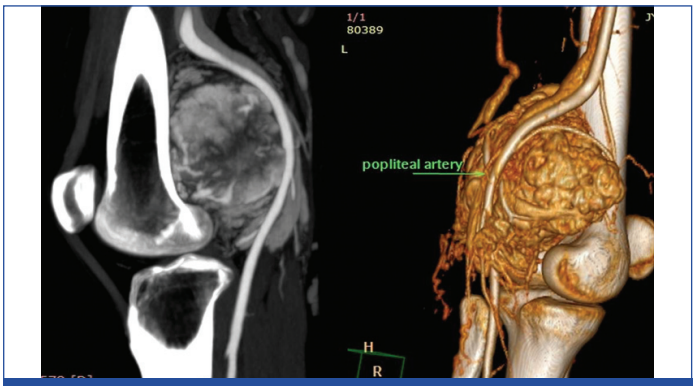
Radiographs revealed abnormal soft tissue density in the popliteal region with no bony abnormalities [Table/Fig-6]. US showed an irregular, heterogeneous, predominantly hypoechoic lesion, which encased and displaced the distal popliteal artery and its branches. Significant vascularity within the lesion was observed on Doppler examination [Table/Fig-7]. CT angiography was performed, revealing a large, heterogeneous, intensely enhancing mass that encased and displaced the popliteal vessels. However, the vessels remained patent, and there was normal contrast filling of the Anterior Tibial Artery (ATA), Posterior Tibial Artery (PTA), and peroneal arteries [Table/Fig-8]. Due to the tumour vascularity, the patient was referred for preoperative embolisation. The transarterial embolisation procedure performed in this case was similar to the aforementioned case [Table/Fig-9a,b]. The embolisation agent used was 100-micron PVA via transarterial access.



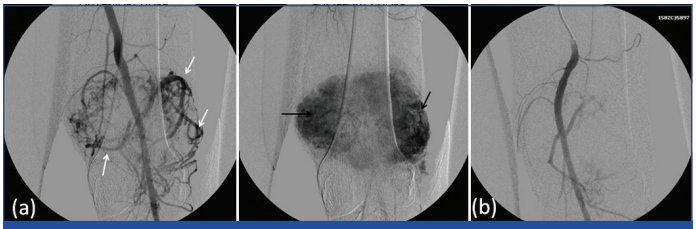
[Table/Fig-6]: Radiograph anteroposterior and lateral views of the left knee show abnormal soft tissue density in the popliteal region with no bony abnormalities (white arrows).



[Table/Fig-7]: B mode and colour doppler ultrasound transverse section showing the predominantly hypoechoic lesion with neovascularity within.

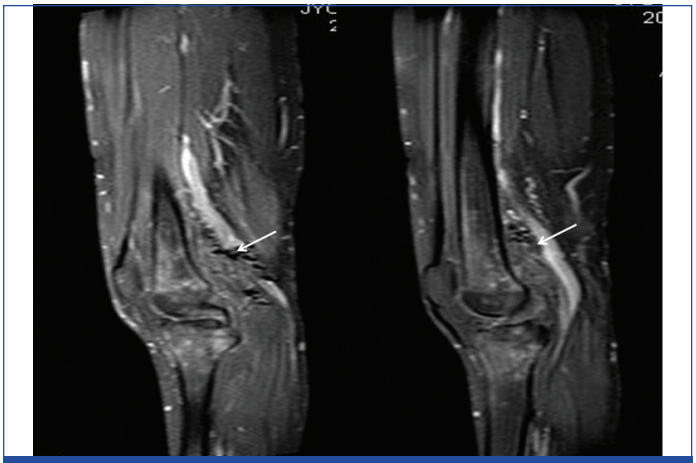


[Table/Fig-8]: CT angiography arterial phase images showing moderate heterogeneously enhancing lesion closely abutting the posterior surface of the femur, displacing and encasing the popliteal artery with patent contrast filling distal arteries.



[Table/Fig-9]: a) Digital subtraction angiography image arterial phase showing multiple branches from popliteal artery supplying the nidus (white arrows) with resultant multiple sites of abnormal vascular blush in the capillary phase (black arrows); (b) Postembolisation check digital subtraction angiography image showing successful embolisation of the arterial feeders with absent abnormal vascular stain and good opacification of distal arteries.

The intraoperative blood loss was approximately 650 mL. Histopathological examination of the operative specimen confirmed the diagnosis of haemangiopericytoma. The patient received radiotherapy postoperatively. After six months of follow-up, an MRI revealed postoperative changes without any recurrence [Table/Fig-10].

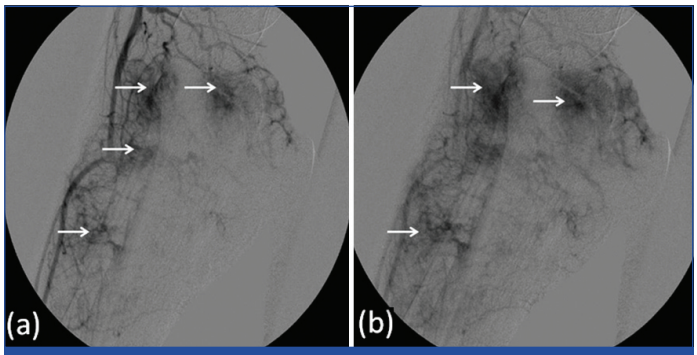


[Table/Fig-10]: A six months follow-up MRI images reveal significant reduction in the tumour volume (white arrows).

Case 3

Malignant fibrous histiocytoma: A 28-year-old female presented to the emergency department with active bleeding from a tumour lesion around the right knee joint, following minor trauma. The lesion had been present for one year, slowly growing. The bleeding continued despite the application of a tight compression bandage. Detailed history revealed a diagnosed case of malignant fibrous histiocytoma. On clinical examination, the swelling measured approximately 8×5 cm and was ulcerated, with active bleeding from one site. Joint movements were restricted, and tenderness was present. Knee joint effusion was also observed.

The transarterial embolisation procedure performed in this case was similar to the aforementioned case [Table/Fig-11]. The embolisation agent used was a mixture of Lipiodol and n-butyl cyanoacrylate glue in a 2:1 proportion, along with PVA particles, administered via transarterial access. A repeat US examination was performed one week after embolisation, revealing a significant reduction in vascular spaces and a decrease in the size of the swelling. The patient was then started on radiotherapy without any further episodes of bleeding.



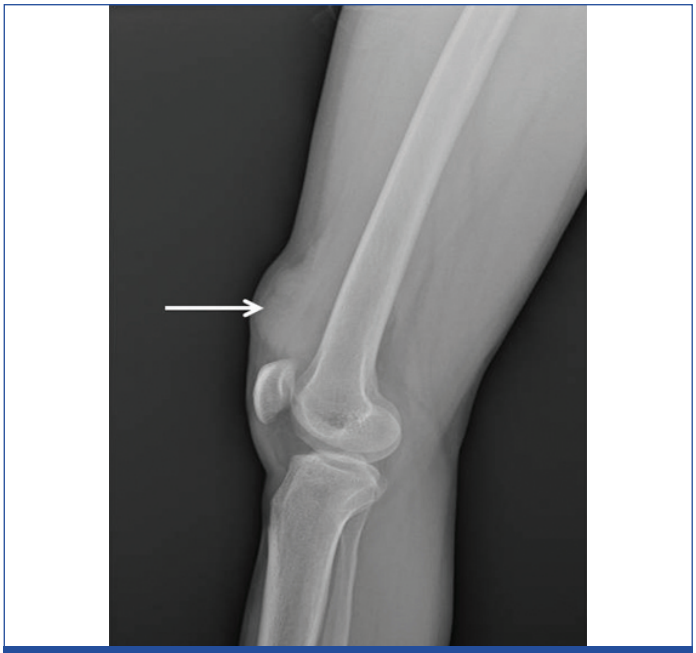
[Table/Fig-11]: Digital subtraction angiography image arterial phase showing multiple branches from popliteal artery, anterior and posterior tibial arteries supplying the lesion (white arrows in (a) with resultant multiple sites of abnormal vascular blush in capillary phase (white arrows in (b).

Case 4

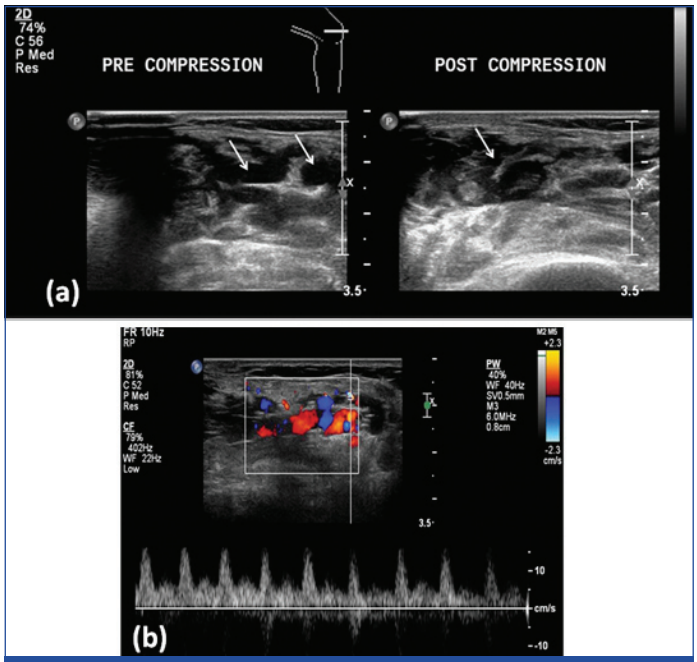
Venous malformation: A 23-year-old male patient presented with complaints of pain and swelling in the right lower thigh for three years. The swelling gradually increased in size. On clinical examination, the swelling was observed in the supra-patellar region of the right lower thigh, measuring approximately 6×8 cm. Upon palpation, it was partially compressible and reducible in size with a refill upon pressure release. There was no significant limitation in the movement of the knee joint, and the peripheral pulses of the posterior tibial and dorsalis pedis arteries were normal.

An X-ray revealed abnormal soft tissue density in the suprapatellar region [Table/Fig-12]. US revealed a lesion with multiple compressible vascular spaces [Table/Fig-13a,b], showing internal low peak systolic velocity blood flow. MRI showed a relatively well-defined lobulated, heterogeneous signal intensity lesion involving the inferior-medial aspect of the thigh. The lesion displaced the adjacent muscles and appeared hyperintense to muscle on T1W [Table/Fig-14a], hyperintense on T2W [Table/Fig-14b] and fat-suppressed T1W sequences [Table/Fig-14c], with the presence of multiple signal voids. The lesion also showed some hyperintense fatty components on the T1W sequence. Post-gadolinium scan revealed strong enhancement [Table/Fig-14d], with retention of the contrast on a 30-minute delayed scan [Table/Fig-14e]. Based on these imaging findings, the diagnosis of venous malformation was confirmed.

Preoperative embolisation: Under US guidance, the vascular spaces inside the lesion were punctured using a 22G scalp vein set. Retrograde free flow of blood was ensured, indicating the position of the needle tip within the vascular spaces. Slow injection of Sodium tetradecyl sulfate (30 mg/mL) mixed with a contrast agent was performed under fluoroscopic guidance into the cannulated vascular spaces [Table/Fig-15]. These steps were repeated until



[Table/Fig-12]: Radiograph lateral view of the right knee shows abnormal soft tissue density in suprapatellar region with no bony abnormalities (white arrow).

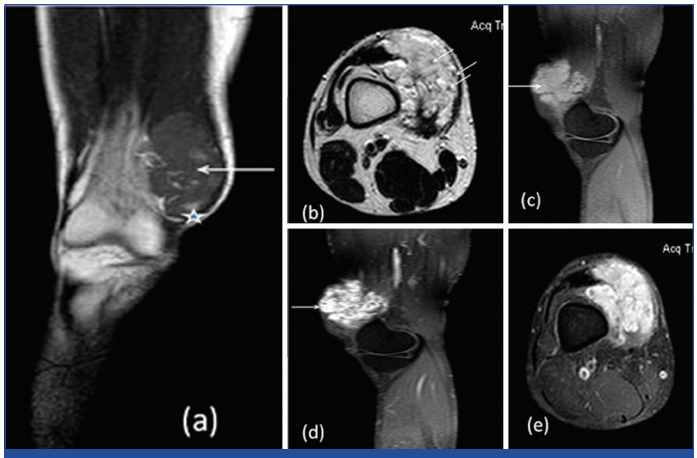


[Table/Fig-13]: a) Pre and post compression B mode ultrasound transverse section showing the lesion composed of multiple compressible vascular spaces (white arrows); b) Pulse doppler ultrasound transverse section showing arterial type of spectral wave form within one of the vascular spaces in the lesion, with peak systolic velocity of 17 cm/s.

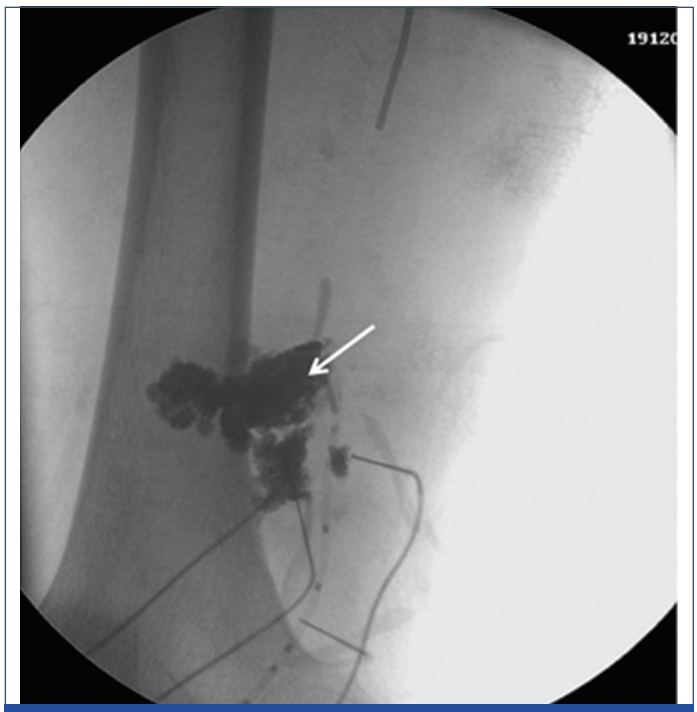
most of the vascular spaces were cannulated and embolised. A repeat US examination one week postembolisation revealed a significant reduction in patent vascular spaces and a decrease in the overall vascularity of the swelling [Table/Fig-16].

DISCUSSION

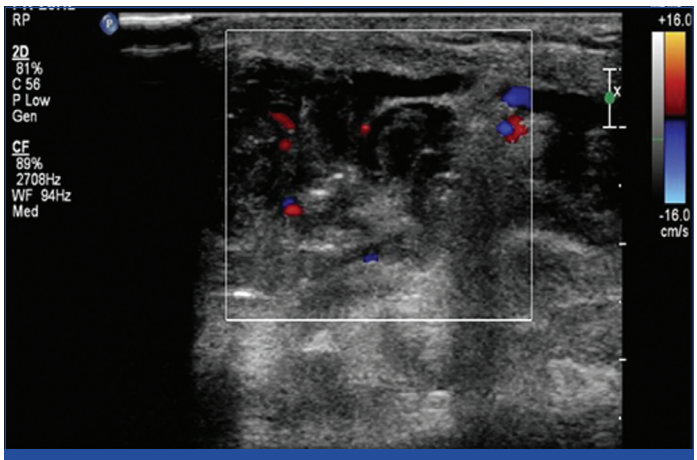
Synovial sarcoma: Synovial sarcomas are malignant tumours commonly seen in adolescents and young adults. About 60% of synovial sarcomas are localised in the lower limbs. The incidence is usually 0.81-1.42 [2]. Their development is typically extra-articular. They can be found anywhere in the body (10% of all soft tissue tumours), but most of them arise in the extremities, particularly near the knee joints [2]. The characteristic finding on imaging is the presence of intratumoural calcification or ossification [3]. Angiography prior to definitive surgery helps differentiate the lesion, evaluate tumour vessels, and prevent bleeding through embolisation [4]. Surgery is the treatment modality of choice, but the tumour often recurs



[Table/Fig-14]: a) T1W coronal image of the right thigh showing heterogeneous, multilobulated lesion (white arrow) with signal intensity slightly hyperintense to adjacent muscles. There was some fatty component noted (asterisk) appearing hyperintense; b) T2W axial image of the right thigh showing heterogeneous, predominantly hyperintense, multilobulated lesion with multiple flow-voids (white arrows); c) T1W sagittal fat saturated image of the right thigh showing heterogeneous, predominantly hyperintense, multilobulated lesion (white arrow); d) Postgadolinium T1W sagittal fat saturated image of the right thigh showing strong enhancement within the lesion (white arrow). The lesion was closely abutting the underlying cortex of the femur without any obvious invasion. There is no intra-articular extension into the knee joint; e) 30 minutes delayed postgadolinium T1W axial fat saturated image of the right thigh showing persistent delayed enhancement within the lesion. The lesion was closely abutting the underlying cortex of the femur without any obvious invasion.



[Table/Fig-15]: Percutaneous embolisation being done under fluoroscopic control with the help of 22 G scalp vein sets (white arrow).



[Table/Fig-16]: Colour doppler ultrasound transverse section showing significant reduction of vascularity within the lesion.

even after wide resection [3]. The prognosis of synovial sarcoma is poor, with almost always recurring and five-year survival rates ranging from 25 to 50% depending on the series [2]. The general principles of transarterial embolisation treatment involve hindering or reducing blood flow to the tumour, resulting in tumour reduction or destruction. This is achieved by injecting embolic agents into the arteries that supply blood to the tumour [2]. Embolisation may be used alone or in combination with other treatments such as surgery, radiation therapy, or systemic therapy [2].

Vascular malformations: Vascular malformations encompass a wide range of anomalies, for which different classification systems have been proposed over time. The important one is given by the International Society for the Study of Vascular Anomalies (ISSVA), based on cellular features, flow characteristics, and clinical behaviour [5]. These lesions, though congenital, are usually asymptomatic at birth and become symptomatic later in adolescence or adult life due to rapid growth, vascular engorgement caused by thrombosis, trauma, infection, or hormonal fluctuations. Symptoms may include ulceration, haemorrhage, cardiac failure, and unwanted cosmetic consequences [6]. Various imaging modalities, such as radiography, Doppler US, CT scan, and MRI, are used, with MRI playing a pivotal role [6]. Angiography is helpful for anatomical assessment and direct puncture of the nidus, which can evaluate the volume and flow pattern of these lesions [6]. Endothelial cells play a role in vascular remodeling, especially at the venous stump, which recruits collateral flow. Interventional techniques involve the use of therapeutic agents targeting the venous stump while avoiding harm to adjacent tissue [7].

Haemangiopericytoma: Haemangiopericytoma is a highly vascular tumour that can be found anywhere in the body where there are capillaries. The cell of origin is the pericytes, contractile spindle cells that surround capillaries and post capillary venules [8]. It is more common in middle-aged individuals [9]. The lower extremity is affected in 35% of cases. It typically presents as an asymptomatic mass or may cause pressure symptoms if it is large enough [8]. Haemangiopericytoma is a highly vascular tumour with clinically significant arteriovenous shunting. Angiographically, the typical feature of haemangiopericytoma is a hypervascular lesion with a few feeder arteries that enter the mass, along with radially arranged branching vessels around and inside the tumour. Longstanding, well-demarcated tumour staining and early opacification of veins due to arteriovenous shunting are also observed [10,11]. Smith RB et al., reported the use of preoperative arterial embolisation in the management of a large pelvic haemangiopericytoma that was previously considered unresectable [12]. Surgery is the treatment of choice, but local recurrence is not uncommon.

Malignant Fibrous Histiocytoma (MFH): MFH is predominantly seen between the 6th and 7th decades of age [13]. The most common site of origin is the extremities [13]. MFH can be a primary tumour or can arise secondarily at sites of previous radiation therapy, surgery, fractures, osteonecrosis, Paget's disease, chronic osteomyelitis, and various benign bony lesions such as fibrous dysplasia, enchondroma, non ossifying fibroma, etc. [14]. Primary MFH can arise from the soft tissue or bones. On angiography, the lesion shows diffuse neovascularity with multiple areas retaining the stain and arteriovenous shunting. Clinical and radiological features of vascular lesions around the knee joint are discussed in [Table/Fig-17].

Role of preoperative embolisation: Successful preoperative embolisation is defined as catheterisation of the tumour-supplying arteries with obliteration of more than 70% of the tumour stain. The goal of preoperative embolisation is to exclude the tumour capillary bed, not just the major arterial feeders. Preoperative embolisation helps reduce intraoperative blood loss, improves visualisation during surgery, and facilitates en-bloc resection [15].

In a study by Jha R et al., preoperative embolisation of bone tumours was found to be a safe and effective adjunct to the surgical management of primary bone tumours, resulting in a reduction in intraoperative blood loss and transfusion volume [16]. Manke C et

Features	Synovial sarcoma	Arteriovenous malformation	Haemangiopericytoma	Malignant fibrous histiocytoma
Age of presentation	Adolescent and young adults	Any age, common in adolescents	Fifth-sixth decade	Fifth decade, the most common primary soft tissue sarcoma in adults
Clinical features	Pain and swelling	Swelling, ulceration, haemorrhage, cardiac failure, and unwanted cosmetic consequences	Swelling various paraneoplastic syndromes	Swelling and mass effect
Radiographs	Periarticular soft tissue mass Calcifications +/- Bony involvement common	Soft tissue mass with/without involvement of bone and joints, phleboliths	Soft tissue mass with calcifications +/-,with/without involvement of underlying bones	Soft tissue mass with involvement of underlying bones, Calcifications +/-
Ultrasound (US) and doppler	Focal, nodular, round or lobulated, solid but hypoechoic soft-tissue mass with vascularity	Multiple compressible vascular channels, with arterial type of waveform in high flow lesions	Heterogenous, predominantly hypoechoic lesion with good neovascularity	Heterogenous, predominantly hypoechoic lesion with good neovascularity
CT scan/CT angiography	Heterogeneous deep-seated soft tissue mass with attenuation slightly lower than muscle, with few hypodense areas of necrosis or haemorrhage, heterogeneous enhancement	Intensely enhancing vascular nidus with feeding arteries and draining veins	Heterogeneous intensity lesion with hypodense necrotic components, heterogeneous enhancement	Large, lobulated, well-defined soft tissue mass that contains areas of decreased attenuation centrally, representing myxoid component/ haemorrhage/necrosis Heterogeneous enhancement
Magnetic resonance imaging	T1W-slightly hyperintense to muscle, T2W-heterogeneous, triple sign, bowl of grapes sign heterogeneous contrast enhancement	T1W-Heterogenous signal intensity T2W-Heterogenous signal intensity lesion, with multiple signal voids Intense contrast enhancement on dynamic contrast scan	T1W-Heterogeneous signal intensity T2W-Heterogeneous signal intensity due to necrosis, haemorrhage and calcifications Heterogeneous contrast enhancement	T1W-Heterogeneous signal intensity, multilobulated mass lesion T2W-Heterogeneous signal intensity, myxoid component appears hyperintense Heterogeneous, predominantly peripheral nodular enhancement
Angiography	Significant neovascularity with arteriovenous blood shunting	Intense vascular enhancement of nidus with a demonstration of feeding arteries and draining veins	Hypervascular lesion with feeder arteries entering mass with radially arranged branching vessels around and inside the tumour with longstanding well-demarcated tumour stain, along with early opacification of veins due to arteriovenous shunting	Diffuse neovascularity with multiple areas retaining the contrast and arteriovenous shunting
Prognosis	Poor, local recurrence common	Good	Poor, local recurrence common	Poor, local recurrence common

[Table/Fig-17]: Table showing clinical and radiological features of vascular masses around knee.

al., reported a significant reduction in intraoperative haemorrhage in patients who underwent preoperative embolisation for spinal metastases from renal cancer using PVA particles, compared to patients who underwent surgery alone [17]. Kickuth R et al., also reported significantly reduced intraoperative blood loss ranging from 200-4000 mL in patients who underwent preoperative embolisation for bone tumours [18]. Wong SJ et al., found that intraoperative blood loss ranged from 150 mL to 6,900 mL, with a mean of 1,173 mL and a median of 500 mL in patients who underwent preoperative embolisation for musculoskeletal tumours [15].

Other advantages of preoperative embolisation include a reduction in the amount of viable tumour, a decrease in the rate of tumour growth, and a potential reduction in the need for radiotherapy and chemotherapy [13]. Tumour embolisation can also be performed as a standalone procedure in a palliative setting for pain relief [17], reduction of tumour volume [18], or in combination with ablation/ cementoplasty [19]. Major complications following preoperative tumour embolisation are rare. The most common complications observed are non target embolisation and postembolisation syndrome [20].

CONCLUSION(S)

Embolisation for highly vascular musculoskeletal lesions is feasible, safe, and highly effective as a primary treatment modality and also as a preparation for definitive surgery. Preoperative embolisation helps reduce intraoperative blood loss, improves visualisation during surgery, and facilitates en-bloc resection. Further large scale studies are needed to validate these results.

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