Benign tumours of foot and ankle

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- Musculoskeletal tumours of foot or ankle make up about 4–5% of all musculoskeletal tumours. Fortunately, about 80% of them are benign. However, due to the rarity and low prevalence of each single tumour entity, diagnosis is often difficult and delayed.
- Ultrasonography is an important diagnostic tool to safely recognize ganglion cysts as a frequently encountered 'bump' in the foot.
- In suspicious lesions, malignancy must be excluded histologically in a tumour center by biopsy after imaging procedures using x-ray, computed tomography (CT) and magnetic resonance imaging (MRI).
- Most of the benign tumours do not require any further surgical therapy. Resection should be performed in the case of locally aggressive tumour growth or local symptoms of discomfort. In contrast to malignant tumours, the primary purpose in the resection is the least possible loss of function.

Introduction

About 80% of all tumours at the foot and ankle are benign. In principle, it is recommended that patients with suspicious lesions are examined and treated in tumour reference centers ([1], [2]). Unplanned surgery often results in the need for more aggressive surgery and/or adjuvant radiotherapy and may adversely affect oncologic and functional outcomes ([2], [3], [4], [5]). The treatment of benign tumours in the foot and ankle region distinctly differs from that of malignant ones. The choice of the respective treatment method depends primarily on the local tendency to recur, the complication rate of the respective method, the opportunities for defect reconstruction, the resulting functional deficits and patient-specific characteristics ([5]). Certain benign tumours, like fibrous dysplasia, non-progressive enchondroma or tumour-like lesions as non-ossifying fibroma (so-called 'leave me alone lesions'), do not necessarily have to be resected. In contrast, local aggressively growing tumours or those that have resulted or may lead to pathological fractures should be treated by surgery, although they are benign. In case of complaints, functional deficits or a threat to stability, an intralesional resection is possible in benign lesions that are less likely to recur ([5], [6], [7], [8]). Surgical treatment of tumours in the foot and ankle area is demanding due to the special anatomy with small compartments, a particularly thin dorsal and highly specialized plantar soft tissue cover, and important neurovascular structures that can easily

be injured ([9]). It may be necessary to cover soft tissue defects or to reconstruct biomechanically stressed areas ([10]). Preoperatively, a precise and comprehensive patient information is essential as, despite intralesional resections, the tumorous destruction can sometimes be massive and adjacent neurovascular structures are at risk for damage during either excision or defect reconstruction. In any case, surgical treatment aims for sufficient resections with low local recurrence rates and a stable skeletal or soft tissue defect reconstruction, i.e. preservation of a functional foot or ankle ([5], [6], [7], [8], [10]).

Diagnosis

Clinical examination

More than 90% of patients present with a local swelling. Pain is described in less than half of the cases ([11]). There are tumour-associated pathological fractures in 1–7% of all cases ([7]) but substantially more frequently (15%) in giant cell tumours ([12]). Complaints often occur due to compression of adjacent structures due to tumour growth. Frequently, there are neurological sensorimotor symptoms due to nerve compression, while ischemic symptoms are rather rare. A good response from pain at rest to non-steroidal anti-inflammatory drugs (NSAIDs) can be an indication for the presence of an osteoid osteoma ([13], [14]).

Due to the absence of pain, fractures or other symptoms and the low prevalence of some tumours in the foot and ankle, diagnosis is frequently delayed (3, 4, 15, 16).

Size, shape, consistency and mobility of the mass are assessed, and possible vascularization and infiltration of tendons or joints are evaluated. The assessment of the skin and soft tissues is essential, also in view of the later surgical planning of soft tissue defect coverage and the detection of potential risks for wound-healing disorders. The occurrence of radiating and shooting pain with or without paresthesia during palpation could be indicative of peripheral nerve compression or a neurogenic tumour.

Imaging

Basic diagnostics include x-rays in at least two planes of the foot and ankle. These are used to detect bony lesions as well as calcified matrix changes, fractures, growth speed and aggressiveness and periosteal reaction (17).

Ultrasound examination can be helpful to visualize extra- and paraosseous lesions and differentiate solid from cystic or liquid soft tissue tumours. However, this is highly dependent on the individual expertise of the examiner. Therefore, every unclear tumour diagnosis requires an MRI of the entire foot and ankle using an intravenous contrast medium (17). It is not only valuable for the detailed assessment of soft tissue tumours but also provides information about the composition and contrast media enhancement of tumours. Central necrosis, peritumoural oedema or tumour-induced bone marrow oedema can be detected to differentiate from simple stress fractures. Aggressive lesions are often accompanied by an infiltration of the normal fat marrow, concomitant oedema and contrast enhancement (2, 16).

For a better and more precise assessment of the bone as well as 3D expansion, composition of the tissue matrix and cortical reaction, additional computed tomography (CT) imaging is most useful (6). In particular, primary benign bone tumours require a CT scan for assessment of bony destruction patterns, osteolytic lesions and tissue matrix. If performed with contrast media, angiographic multiplanar 2D- and 3D reconstructions allow for a detailed visualization of size and course of supplying blood vessels. Technetium bone scanning represents an unspecific but sensitive method for assessing the metabolic activity of the tumour, particularly in the early stages of some lesions like osteoid osteoma.

Biopsy

All tumours with slightest suspicion of malignancy require histopathological proof by biopsy (2, 7, 16). To prevent wrong indications and avoidable complications, biopsy must be planned by an interdisciplinary tumour board in a designated tumour centre according to strict oncosurgical guidelines (1, 3, 4, 5, 11, 18). In case of small and in radiomorphologically benign tumours, this can be conducted as an excisional biopsy (6). In suspicious lesions, core needle or open incisional biopsy is preferable (6). Fine needle biopsy for soft tissue tumours is no longer recommended. The highest diagnostic accuracy is achieved with the open incisional biopsy by examining sufficient and representative amounts of tissue (5). Primary resectional biopsy is allowed in small tumours (<3 cm), which are superficial and clearly separated from underlying fascia or other deep anatomical structures.

Soft tissue tumours

Ganglion

The majority of soft tissue tumours at the foot and ankle are benign (6, 7, 17, 19, 20, 21, 22). The commonest benign lesion is a ganglion arising from synovial tissue in areas of physical stress. They are rather of degenerative than neoplastic origin (tumour-like lesions). Ganglia consist of a synovial capsule that is connected to a joint or tendon and are filled with mucous fluid and therefore transilluminate on the torch test. A firm subcutaneous lump is found most commonly at the dorsum at the foot. Ganglia typically wax and wane in size and may disappear or perforate spontaneously. They are resected only when causing mechanical irritation, mostly at the dorsum of the foot or in the tarsal tunnel, or when treating the underlying joint or tendon pathology. The stalk of the ganglion is dissected and ligated to reduce the risk of recurrence.

Fibroma

Fibromas are benign fibroblastic tumours interspersed within collagen fibres. They present as firm, well-demarcated nodules that are usually mobile and not tender on palpation. Resection is recommended in case of local, mostly compression-induced pain or interference with the sliding tissue of the paratenon.

Plantar fibromatosis (Ledderhose's disease)

Plantar fibromatosis is a relatively frequent tumour caused by hyper-proliferation of abnormal fibrous tissue within the plantar fascia that also involves the plantar skin. It can be associated with other fibromatous lesions like palmar fibromatosis (Dupuytren's disease) and induratio penis plastica (Peyronie's disease). It is more common in men than women, especially of Northern European origin, and prevalence rises with age. It takes the characteristic form of nodules and cords that may be painful when walking (23). Treatment is nonsurgical with shoewear modification and analgesics. Because of the benign nature but high recurrence rate and the potentially disabling scar at the

plantar skin resulting from total fasciectomy, surgical treatment is often symptomatic with local excision of painful chords and lumps (5). If total fasciectomy is carried out to achieve radical resection, a curved incision over the non-weight-bearing sole is preferred to avoid scar contracture (24). Factors associated with recurrence are multiple nodules, bilateral disease and a family history of fibromatosis (23). Full-thickness plantar skin excision and skin grafting should be avoided even in cases of dermal infiltration because of the critical scarring with a high risk of hyperkeratosis at the sole of the foot (5).

Desmoid tumour (aggressive fibromatosis)

Desmoid tumours are benign fibrous tumours that may appear in any fascia of the body, including the plantar fascia and display a more aggressive growth and high local recurrence rates of up to 77%. The foot is the second most frequent localization after intra-abdominal desmoids (10, 25). Resection with a margin of at least 1 cm is generally proposed in order to lower the recurrence rate and may require plastic coverage (10, 26). However, there is evidence that microscopically positive margins do not adversely affect recurrence rates (27). On the other hand, long periods of stable size and even regression of desmoid tumours has been observed with nonoperative treatment (5). Radiotherapy has been suggested in the past (28). More recently, anti-inflammatory and hormonal medication have been successfully applied as alternative treatment options (29).

Schwannoma (neurilemmoma)

Schwannomas are encapsulated solitary tumours (Fig. 1) that arise from the Schwann cells of the nerve sheath. The patients are usually in the fourth or fifth decade of life. Percussion elicits pain or dysesthesia along the further course of the affected nerve (Hofmann Tinel sign). Symptomatic Schwannomas are carefully enucleated from the nerve sheath under loupe magnification in a discrete plain between the tumour and the nerve fascicles.

Neurofibroma

Neurofibromas are spindle cell tumours of peripheral nerves that are solitary in about 90% of cases and part of neurofibromatosis with multiple lesions in 10%. Neurofibromas at the foot and ankle should always raise the suspicion of the latter (30). Neurofibromatosis type 1 (NF1) may present with localized gigantism and scoliosis (31). Patients present with multiple cutaneous café au lait-spots and plexiform neurofibromas. Neurofibromas at the foot can grow to a considerable size and involve skin, subcutaneous and deep tissues including nerve fibres. The surgeon therefore has to weigh the symptoms caused by the lesion and the expected morbidity of surgical resection. In NF1, there is a 10% chance of malignant transformation (31).

Interdigital neuroma

Interdigital neuromas in the second to fourth web space (Civinini's or Morton's neuroma) are widely believed not to be real neoplasms but rather reactive lesions secondary to local pressure (5). Consequently, resection and decompression of the intermetatarsal ligament seem to be equally effective. Alternative treatment options include injection of anaesthetics, alcohol, corticosteroids and capsaicin.

Glomus tumour (glomangioma)

Glomangiomas are particular neurovascular malformations typically located at the tips of fingers and toes, mostly subungually. There is a male-to-female ratio of 1:3 (8). They consist of an agglomeration of arteriovenous anastomoses surrounded by a network of nerve fibers. A sharp localized pain may be elicited on palpation or by applying a cold stimulus on the affected
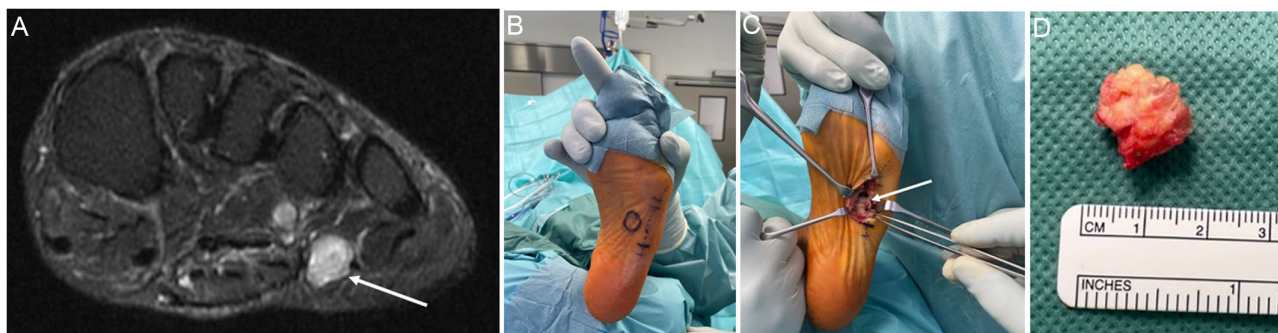
Figure 1

(A, B) A 72-year-old female patient with known schwannomatosis presents with a new lesion on the sole of the left foot with pain when walking. MRI reveals in T2-weighted fat-saturated coronal sequence showing focal tumour with high signal intensity. (C–D) Excisional biopsy confirmed histological evidence of schwannoma.

toe. They have a red to livid appearance in the nailbed, and the differential diagnosis should therefore include a subungual malignant melanoma. Radiographs show the typical scalloping appearance of the terminal phalanx. The glomus tumour is resected under local anaesthesia with longitudinally splitting and readapting the nailbed.

Hemangioma

Hemangiomas at the foot mostly present as a capillary type, less frequent as a cavernous or mixed type. They appear as a bluish, doughy mass. Plain radiographs show multiple phlebolites. MRI reveals the extent of the lesion with the characteristic 'cluster of grapes' appearance. They may be associated with localized gigantism like Proteus or Klippel–Trénaunay syndrome. Hemangiomas respond well to NSAIDs or compression therapy (32). Sclerotherapy and embolization have been shown to be effective as was oral propranolol in children up to 5 years of age (33). Resection is only warranted with local pressure symptoms. Local recurrence rates are relatively high and may be reduced by selective preoperative embolization. Lymphangiomas share many features of hemangiomas (33).

Lipoma

Lipomas are the most frequent benign soft tissue tumours at the foot and ankle but still rare compared to other locations in the body because of the relative paucity of fat tissue. They are doughy in consistency, and like fibromas they are located subcutaneously and usually are asymptomatic, nontender and mobile. They are resected only if they cause local symptoms. The risk of local recurrence is low with marginal resection (Fig. 2).

Localised (nodular) tenosynovial giant cell tumour

Localized (nodular) tenosynovial giant cell tumours (TGCT, benign fibrous histiocytoma and fibroxanthoma) of tendon sheaths occur far more often at the hand than at the foot. The forefoot is involved more frequently than the hindfoot and the plantar aspect more often than the dorsal aspect (34). They mostly present as painless, slowly growing, well-defined firm nodules that may disappear spontaneously. Marginal excision is warranted for symptomatic tumours (interference with the sliding tissue of the paratenon) only, and recurrence rates are considerably lower than at the hand (34).

Diffuse-type TGCT

The diffuse form of TGCT (diffuse-type TGCT), previously referred to as pigmented villonodular synovitis (PVNS), is a relatively frequent, locally aggressive growing tumour arising from synovial tissue of joints, tendon

sheaths or bursal linings (Fig. 3). The lesion displays a dark brown pigmentation resulting from hemosiderin deposits and can cause erosions at the cartilage and bone. The localized type of TGCT is usually observed at the ankle or forefoot, while the diffuse type tends to be panarticular (35). The symptoms are mostly nonspecific and erroneously indicative of an infection, leading to the incorrect term 'synovitis' with pain, swelling and effusion at the affected joint or along nearby tendons. Radiographs may reveal juxtaarticular bony erosions. MRI shows the massively thickened synovium and the typical low T1 and low T2 signal (36). Histologically, diffuse-type TGCT is identical to localized TGCT, the distinction is made by the anatomic location. Open total synovectomy is the treatment of choice to prevent recurrence (35, 37). At the ankle joint, this requires separate anterior and posterior incisions. Extensile bone and joint erosion may warrant fusion (11, 35). The local recurrence rates vary between 30% and 60%, with complete tumour resection being an important prognostic factor (5), while arthroscopic resection and diffuse-type TGCT increase the risk for recurrence (35). The value of adjuvant radiation or radiosynoviorthesis in extensile disease is debated, but it has been applied successfully for relapses or refractory cases (35). Intraarticular injection of ^{90}Yttrium into the ankle was associated with inacceptably high complication rates (38).

Synovial chondromatosis

Synovial chondromatosis is very rare at the foot and ankle. It consists of multiple cartilagioneous or osteocartilagineous nodules within the synovium. Arthroscopic or open synovectomy is indicated in the presence of symptomatic, intraarticular loose bodies. Long-standing disease may lead to degenerative arthritis and, in less than 10%, malignant transfomation (39).

Skin conditions

Benign skin conditions like dermatofibroma and granuloma annulare usually resolve spontaneously. Basaliomas are predominantly seen on the dorsum of the foot while epitheliomas usually affect the sole (5). Wide resection and secondary coverage with local flaps is the treatment of choice.

Bone tumours

Simple (unicameral) bone cyst

Bone tumours with numerous cystic lesions of benign nature can be seen at the foot and ankle (40, 41). Simple (unicameral) bone cysts (SBCs, Fig. 4) are found in up to 11% at the calcaneus (5). They are mostly asymptomatic
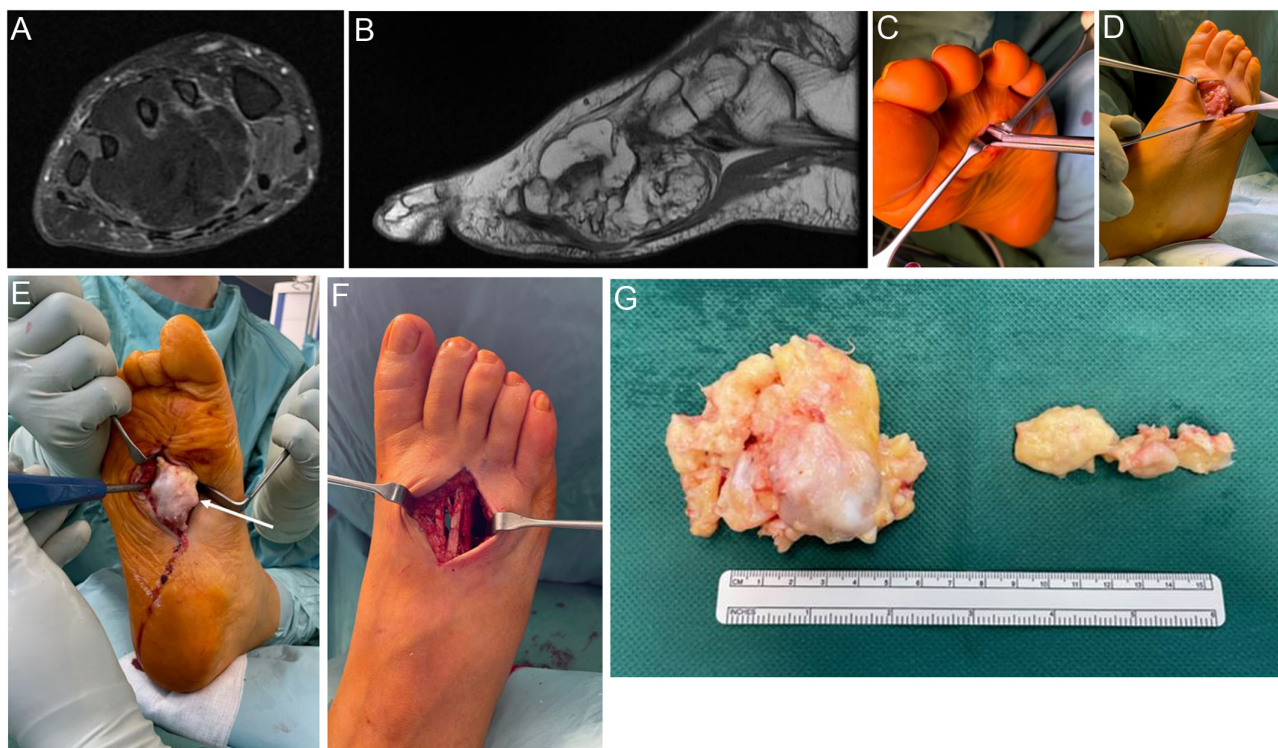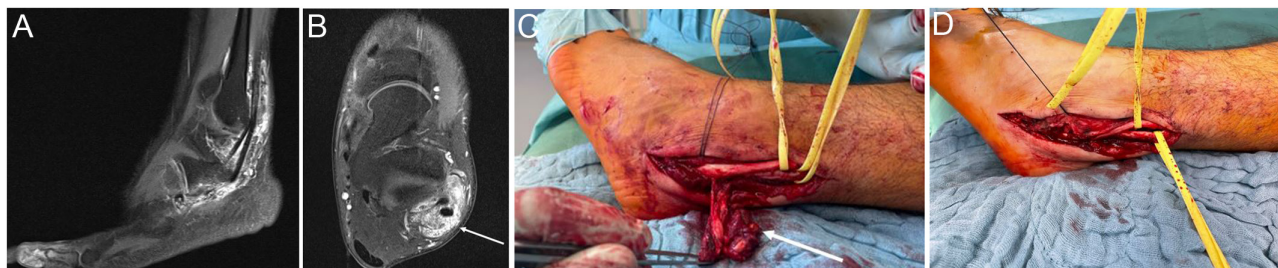
Figure 2

(A, B) MRI of a 69-year-old patient with massive tumour growth around the second-to-fourth metatarsals and pain when walking. In MRI, the proton density fat-saturated coronal sequence showing hypointense tumour signal, corresponding sagittal non-contrast T1-weighted sequence showing hyperintense tumour signal. (C) Biopsy showed evidence of a lipoma with metaplastic cartilage and bone formation. (D–G) Definite treatment consisted of marginal resection via plantar and dorsal approaches with exposure of the metatarsals.

and typically located in an area with a physiologically rarified trabecular architecture, the 'neutral triangle' (11). They consist of a thick cortical shell lined with a membrane and are filled with fluid or mucus. Most are detected accidentally and are simply observed if asymptomatic. Pogoda *et al.* (41) observed pathologic calcaneal fractures in 8% of 50 SBCs. They proposed curettage and bone grafting of large SBCs with an extension of 100% of the

intracalcaneal diameter in the coronal plane and more than 30% in the sagittal plane because these cysts tend to be symptomatic and have a higher risk of fracture. However, this does not guarantee complete relief of pain (42). Alternative treatment options for symptomatic cysts are steroid injections and the introduction of Kirschner wires or cannulated screws for continuous decompression and drainage (14).

Figure 3

(A, B) MRI of diffuse-type tenosynovial giant cell tumour (TGCT) in a 30-year-old man, T1 fat-saturated injected sequences showing enhancement of the nodular structures. (C, D) After biopsy and exclusion of malignant lesion, marginal resection with protection of the peroneal tendons was performed.
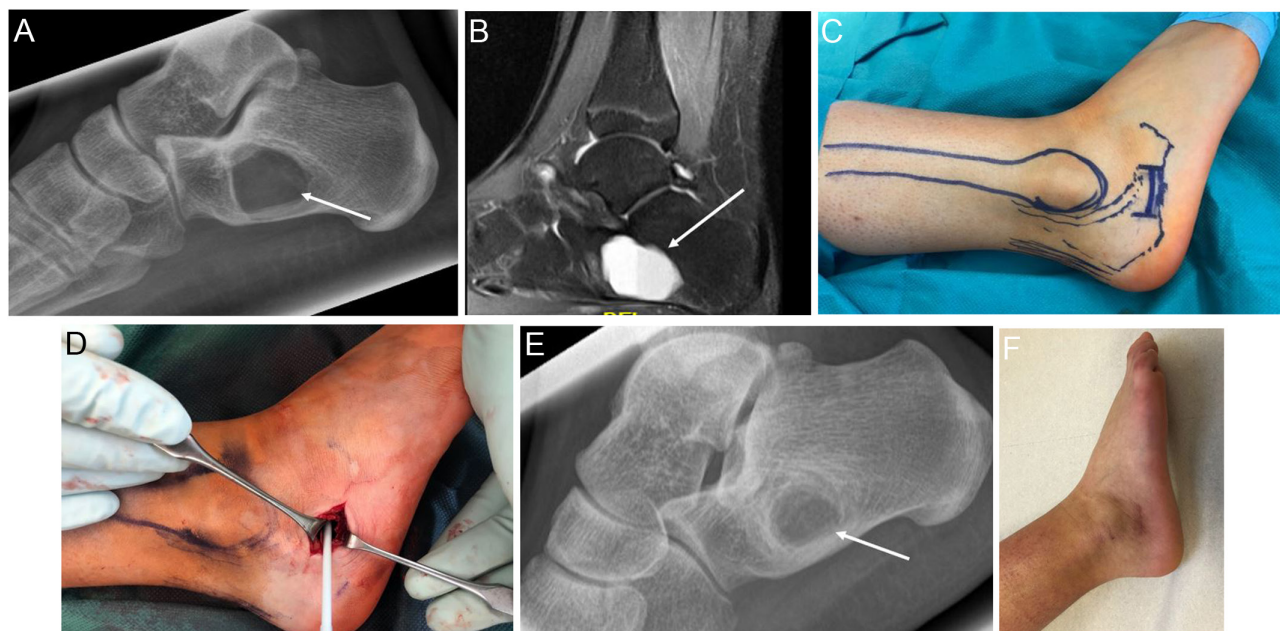
Figure 4

(A) Lateral radiograph with osteolysis and (B) MRI sagittal view with high tumour signal intensity in T2 TIRM sequences of a juvenile bone cyst in the right calcaneus in a 15-year-old patient. (C) A lateral approach was used for enucleation, curettage and defect filling with a biphasic injectable bone graft substitute (CERAMENT, Bonesupport, Lund, Sweden) (D). It is a composite of synthetic hydroxyapatite as osteoconductive component and resorbable calcium sulphate. At 9 months postoperatively, there is a stable calcaneus with progressive bone growth and full return to physical activity (E, F).

Intraosseous lipoma

Cysts with a central calcification are likely to represent a less frequent intraosseous lipoma (43, 44), but the distinction between SBC and lipoma can be facilitated by fat-saturated or T1-weighted sequences in the MRI and definitely (43). The differential diagnosis also includes degenerative cysts that can reach a considerable size (11). The latter are accompanied by symptomatic arthritis or chondromalacia and communicate with the affected joint. In these cases, curettage and bone grafting is followed by fusion of the affected joint. Intraosseous ganglia are typically asymptomatic and found accidentally at the medial malleolus. They may communicate with the ankle joint or the posterior tibial tendon sheath. Curettage, drilling and bone grafting are only warranted in the rare symptomatic cases (14).
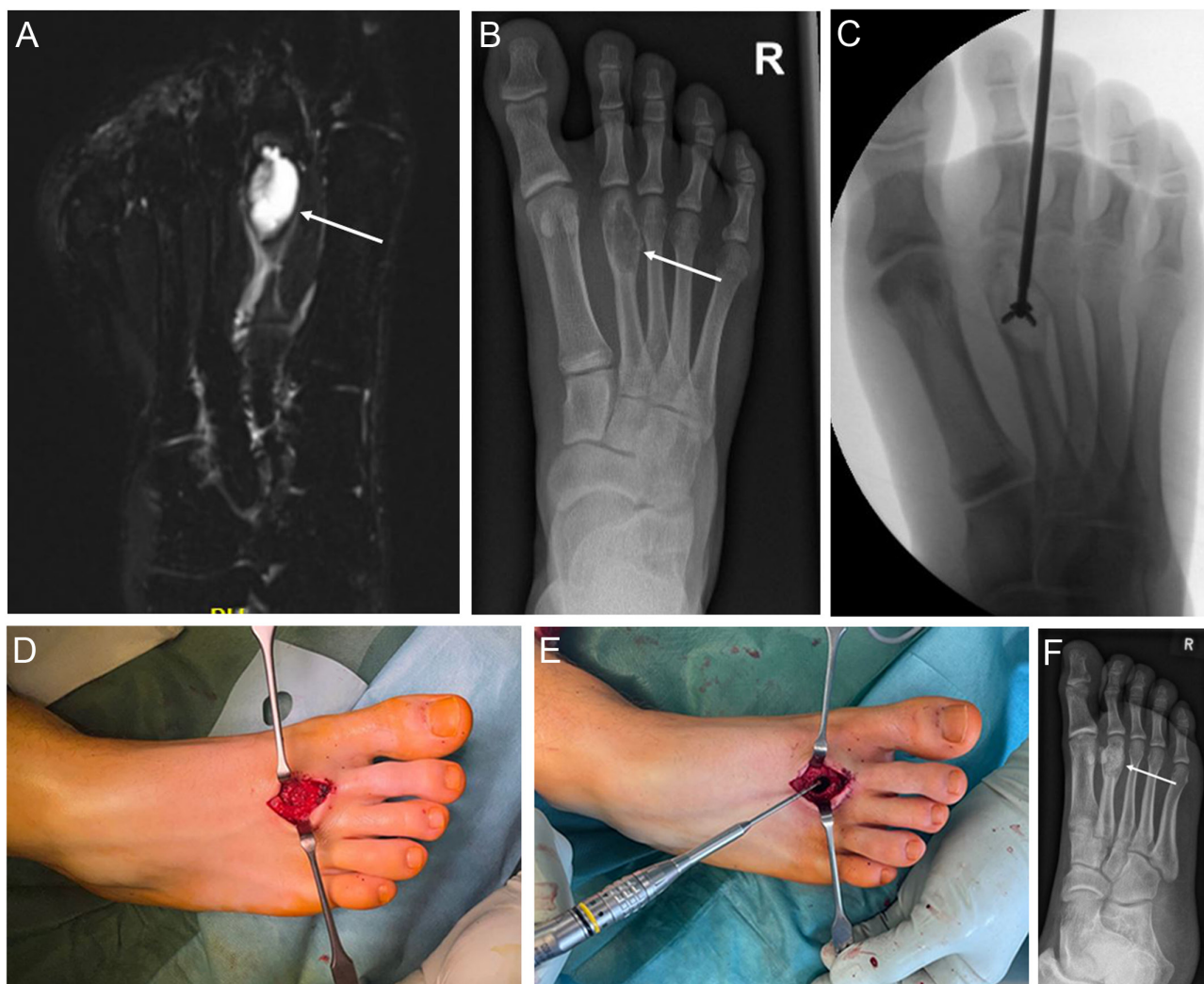
Aneurysmal bone cyst

Aneurysmal bone cysts (ABCs) are relatively frequent benign lesions of disputed origin. They usually occur in patients in their second decade of life. The foot is affected in 4–6% of cases and the distal fibula in 7–16% (45, 46, 47). Plain radiographs reveal the typical multicystic appearance with multiple fluid levels, resembling a honeycomb or map with cortical thinning and expansive growth, i.e. bulging ('blow out phenomenon'). Aneurysmal

bone cysts are filled with blood, fibroblasts, osteoclast-like multinuclear cells and reactive woven bone. The treatment of choice is curettage and bone grafting (Fig. 5) with a local recurrence rate of 20% at the foot (46). Large lesions may be pretreated by angiographic embolization. Radical resection is not indicated considering the benign nature of the lesion and the high success rates even with repeat curettage. Percutaneous intralesional injection of the sclerosing agent polidocanol has been reported to have a recurrence rate of only 2.8% (45, 48). In a study with percutaneous placement of intralesional doxycycline, Shiels *et al.* reported evidence of healing and cortical thickening in all 20 cases reviewed with a recurrence rate of 5% (47). Secondary ABCs may be seen in association with underlying primary bone tumours, mostly osteosarcoma or chondromyxoid fibroma (CMF) (epiphenomenon), and insidiously mask the underlying malignancy. Particularly in cases with solid parts, an extended preoperative imaging (contrast MRI and PET) and incisional biopsy is mandatory prior to intralesional curettage.

Enchondroma

Enchondromas are typically asymptomatic, solitary, intramedullary cartilagineous tumours that are most frequently found at the tubular bones of both hands and feet. Radiographs show a well-demarcated ovoid

Figure 5

(A) MRI of an aneurysmal bone cyst with high tumour signal intensity seen on the T2-weighted imaging and eccentric lucent bone lesion on x-ray (B) in a 17-year-old male patient with aneurysmal bone cyst confirmed by biopsy (C). Surgical treatment consisted of enucleation, curettage, milling the cyst cavity (D, E) and defect filling with allogeneic cancellous bone graft (F).

lesion with stippled calcifications. Isolated lesions can present with pathological fractures at the metatarsals or toes. Treatment consists of immobilization until fracture healing followed by curettage and bone grafting. The latter is also recommended for symptomatic lesions without a fracture with low rates of recurrence (49). Asymptomatic enchondromas should be followed radiographically. Multiple enchondromas are called Ollier's disease and carry the risk of malignant transformation in about 30–40% (5). If associated with additional multiple soft tissue hemangiomas, it is called Maffucci syndrome. Radiographic signs of malignant transformation like endosteal cortical exfoliation and scalopping are less reliably found at the foot compared to the long bones.

Osteochondroma

Osteochondromas (cartilagineous exostoses) are mostly solitary lesions in the metaphyseal region of tubular bones. They are sessile or peduncluated and grow away from the physis. Resection is warranted only in case of mechanical local symptoms. Care has to be taken to remove the entire cartilage cap without damaging it to avoid local recurrence. Subungual exostoses are rather painful because of local pressure. They are resected with splitting of the nail and nailbed if needed after a subungual melanoma (SUM) has been ruled out. A rare variant is the bizarre paraosteal osteochondromatous proliferation of bone (BPOP or Nora lesion) that also occurs predominately on the tubular bones of hands and feet

(50). It exhibits a locally aggressive growth and is believed to result from a florid reactive periostitis (5). Radiographs show ossifications without cortical reaction or medullary changes. Complete resection of symptomatic lesions is fraught with recurrence rates of 29–57% (50).

Non-ossifying fibroma

Non-ossifying fibromas (NOF) are usually asymptomatic benign lesions, which typically cluster in the age group 10–15 years. On conventional radiographs, the typical grape-shaped configuration of the eccentric, cortical and metaphyseal change is seen, usually surrounded by a polycyclic sclerotic rim. If this typical conventional radiological picture is present in the appropriate age group, then no further diagnosis is required in addition. Remodeling occurs as part of the physiologic growth of the bone, which limits the change itself and therefore makes it a so-called 'leave me alone' lesion (14). Rarely, unstable lesions with load-dependent complaints or even pathological fractures are seen, which are then treated surgically with curettage and cancellous bone grafting, and, if necessary, osteosynthesis is performed (14). At the distal tibia metaphysis, the lesion is frequently observed. No cases have been reported in the foot.

Langerhans cell histiocytosis

The predilection age of Langerhans cell histiocytosis (LCH), historically also referred to as eosinophilic granuloma, is the first and second decade of life. The clinical presentation ranges from benign solitary findings with spontaneous remission without therapeutic consequence to multilocal osseous (Hand–Schüller–Christian disease) or even malignant courses with multiple-organ involvement (Abt–Letterer–Siwe disease). However, surgical intervention is rarely necessary after the necessary biopsy owing to its aggressive appearance to exclude Ewing's sarcoma, neuroblastoma and osteomyelitis. Only lesions threatening stability with impending fracture force surgical treatment. Local excochleation with or without cancellous bone grafting is the treatment of choice.

Fibrous dysplasia

Fibrous dysplasia may be monostotic or polyostotic. In the polyostotic form with additional occurrence of endocrine disorders, a McCune–Albright syndrome is present, in combination with subcutaneous myxomas as Mazabraud syndrome. The cause of fibrous dysplasia is a somatic mutation of the GNAS gene on chromosome 20. Radiologically, a soap bubble-like, honeycombed cystic pattern is seen with often marked distension of the bone and thinning of the cortical bone. Conventional radiography and CT typically describe a milky glass-like change. Therapy for fibrous dysplasia is usually conservative. Bisphosphonates may be used if pain is reported. Surgical therapy is indicated mainly in cases of pronounced deformities and fractures.

Osteoid osteoma

Osteoid osteoma is the most prevalent benign bone tumour at the foot and ankle, accounting for up to 35% of all biopsied benign neoplasms (51). It is predominately seen in patients between 5 and 30 years of age. The male-to-female ratio is 2:1. A multifocal presentation may be associated with clonal deletion on chromosome 22 (51). The classical appearance with a small radiolucent nidus surrounded by sclerotic bone is not always obvious on plain radiographs but can be reliably detected with CT scanning or MRI. It may be missing in juxtaarticular locations, e.g. distal tibia and talus, with no cortical periosteum layer. Bone scans show a hot spot. The pain typically occurs nocturnal and responds to NSAIDs (13, 52). However, in a recent series of 12 children aged 8–16 years with lesions at the foot, nocturnal pain and relief with NSAIDs occurred in only half of the cases with no correlation between the two findings (5). Atypical symptoms included hip referring pain, extensor tenosynovitis and Achilles tendon atrophy. Osteoid osteoma at the foot and ankle is usually located subperiosteally. The talus is affected most commonly, followed by the calcaneus. Location at the hindfoot may cause symptoms of posterior impingement or sinus tarsi syndrome (5, 53). Osteoid osteoma may be a self-limiting disease with the potential to resolve over a course of 2–3 years (54). Nowadays, symptomatic and radiographically distinct osteoid osteomas are effectively treated by either CT- or MRI-guided percutaneous radiofrequency (RFA) or thermoablation (54, 55, 56, 57). Recurrences may be either treated with percutaneous ablation or then curetted with complete resection of the nidus and defect filling with bone graft (14). Recurrence rates are reported between 0% and 12% after resection (5, 14) and between 0% and 24% with percutaneous ablation techniques (57). En bloc resection with surrounding bone as classically recommended results in restricted function and does not seem to improve local tumour control. Percutaneous resection and ethanol resection is discouraged at the foot and ankle because of the lack of precise control over the amount of tissue damage (58). Percutaneous interstitial laser photocoagulation has been reported to have similar results like RFA (59).

Osteoblastoma

If the nidus has a larger diameter than 1.5 cm, the tumour is called osteoblastoma. It typically occurs in patients between 15 and 30 years of age. Osteoblastomas are

typically seen at the talar neck and do not respond to NSAIDs (14). Because these tumours continue to grow locally, curettage is the treatment of choice. Defect filling can be achieved with bone grafting or bone cement. Filling with polymethyl methacrylate (PMMA) has the advantage of high primary stability, increase in local control due to thermal effects along the margins during exothermic polymerization and potentially earlier detection of osteolytic recurrence because of the good delineation of the radiopaque cement (11, 59).

Chondroblastoma

Chondroblastoma, although generally considered a benign lesion, has the rare potential to metastasize to the lung (14). The overall reported lung metastases rate in the pooled literature review (larger series only) was 0.4%, all patients were skeletally mature (60). It typically occurs in epiphyses of young, skeletally immature male patients. At the foot and ankle, the talus and calcaneus are mostly affected and patients are often beyond maturity. Radiologically, subchondral lesions with a slight reactive rim are seen. Biopsy is essential for making the diagnosis

(14). Histologically, benign chondroblasts with no atypia are found with associated giant cells and a thin layer of mineralized matrix. Curretage is the treatment of choice, and recurrence at the foot and ankle or metastatic spread from distal lesions seems to be rare. The recurrence rate is described as about 15% after surgical therapy, especially in the case of incomplete removal (60).

Chondromyxoid fibroma

Chondromyxoid fibromas (CMFs) are less common than chondroblastomas, but about 17% of cases occur at the foot and ankle (61). As with chondroblastoma, radiographs are nonspecific and biopsy is required for diagnosis. Treatment usually consists of curettage with recurrence rates between 20% and 25% (61). Bone grafting is needed for extensive tumours with destructive growth.

Giant cell tumours of bone

Giant cell tumours (GCT) of bone are benign lesions that carry a high risk of pathologic fracture and recurrence. Moreover, malignant transformation is reported in up to 10% and systemic metastasis in 1–4% (62, 63). About 4%
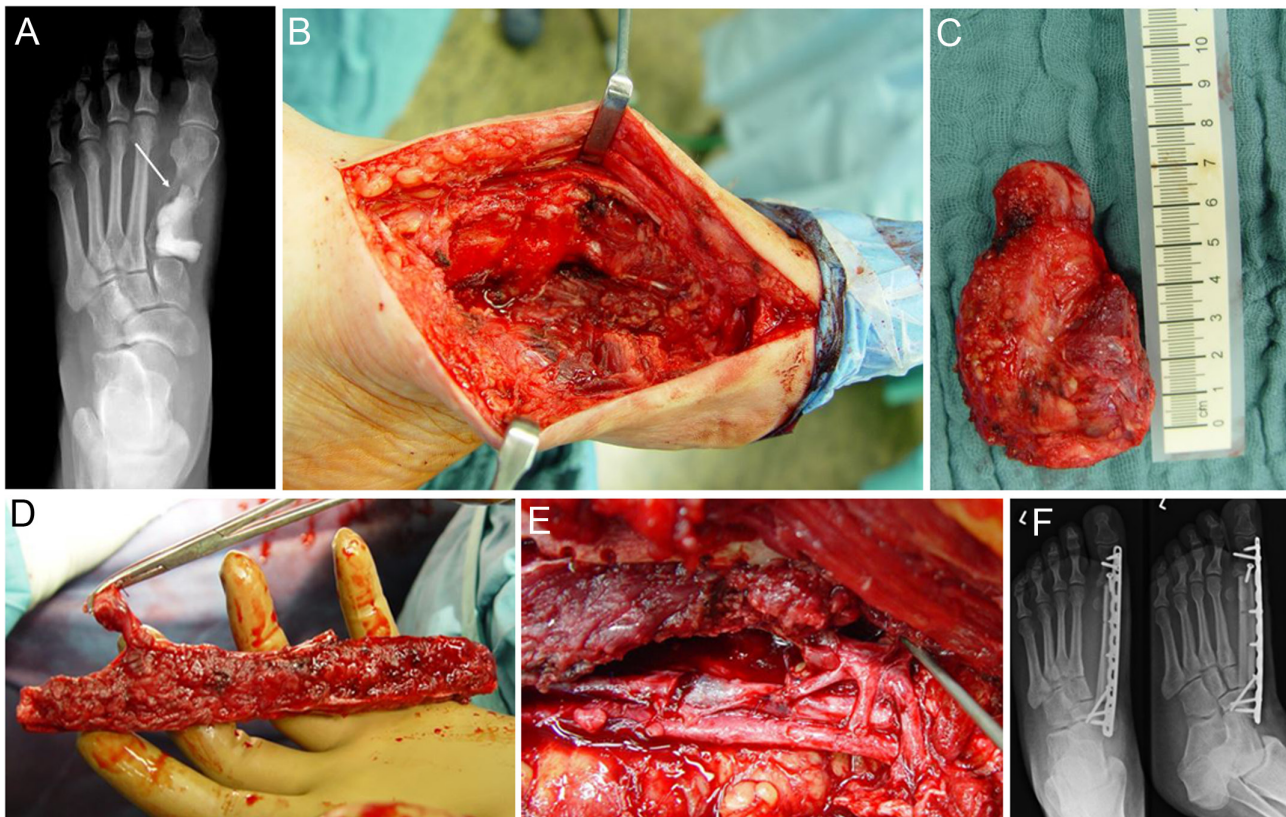
Figure 6

A 37-year-old female patient with recurring giant cell tumour after excochleation and cement augmentation (A). Complete resection of the first metatarsal (B, C) and reconstruction with a vascularized fibula and locking compression plate (LCP, DePuy-Synthes, West Chester, PA, USA) (D,E,F).

of cases occur at the foot and ankle (63, 64). The ankle region (including the talus) and calcaneus are mostly affected and the age peak lies between 20 and 40 years (63, 64). Giant cell tumours present as eccentric and expansive radiolucent lesions with a small rim of reactive bone. Curettage with high speed burrs and bone grafting is the mainstay of treatment but associated with a 25–50% risk of recurrence (Fig. 6). On the other hand, joint salvage was possible in 84% in a series of 139 patients with pathologic fractures due to GCT (65, 66). Wide excision at the foot has a considerably lower risk of recurrence (0–5%) but mostly requires fusion of adjacent joint(s) and thus loss of function (63). Adjuvant therapies like bone grating, cryotherapy with liquid nitrogen and radiotherapy have mixed results (63, 66). A retrospective study on 384 GCTs on different localizations showed a significantly lower recurrence rate after intralesional resection and defect filling with PMMA cement, while other adjuvant therapies like phenol cauterization did not have any measurable effect (66). Denosumab is recommended as the first option in inoperable or metastatic GCT. It has also been used preoperatively to downstage tumours with large soft tissue extension (67).

Key points

1) The majority of tumours at the foot and ankle are benign.
2) Basic diagnostics include x-rays and every unclear tumour diagnosis requires an MRI of the entire foot and ankle using intravenous contrast medium.
3) All tumours with slightest suspicion of malignancy require histopathological proof by biopsy.
4) Most of the benign tumours do not require any further surgical therapy.
5) In case of complaints, functional deficits or a threat to stability, an intralesional resection is possible in benign lesions that are less likely to recur.
6) Resection should be performed in the case of locally aggressive tumour growth or local symptoms of discomfort.
7) In contrast to malignant tumours, the primary purpose in the resection is the least possible loss of function.
8) Depending on the biological activity, clinical complaints and stability, the bony defects are filled (bone grafting or bone cement) and, if necessary, osteosynthesis is performed.
9) Using adjuvant treatments can reduce the risk of recurrence.

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