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CASE REPORT

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Fibrous dysplasia with cartilaginous differentiation ("fibrocartilaginous dysplasia"): a review, with an illustrative case followed for 18 years

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Abstract A 21-year-old man with an 18-year history of progressive, and deforming, monomelic fibrous dysplasia with massive cartilaginous differentiation (fibrocartilaginous dysplasia) is described. A review is made of all prior reported examples of this entity in the English language medical literature. The radiologic and histologic differential diagnoses are described, distinguishing the lesion from chondrosarcoma and from fibrocartilaginous mesenchymoma.

Keywords Fibrous dysplasia · Fibrocartilaginous dysplasia · Fibrocartilaginous mesenchymoma

Introduction

Fibrous dysplasia (FD), a dysplastic process of the bone-forming mesenchyme, is histologically characterized by a benign-appearing spindle cell fibrous stroma containing scattered, irregularly shaped trabeculae of immature (woven) bone, lacking osteoblasts, that evolve directly from the stroma [1, 2, 3, 4]. The long bones, especially the femur, the ribs and craniofacial bones are the commonest sites of involvement, the process either being limited to a single bone or, less commonly, affecting multiple bones [1, 5, 6, 7, 8, 9]. Radiologically, FD is usually a well-delimited lesion whose appearance ranges from lucent to radiodense depending upon the relative proportions of the fibrous and osseous tissue within it. The bone is frequently expanded and, in severe cases, markedly deformed with extreme bowing and angulation, the latter secondary to pathologic fractures [1, 7, 10, 11].

In a small percentage of cases FD contains nodules of hyaline cartilage in amounts that vary from microscopic foci to large, grossly evident masses [12, 13, 14, 15, 16]. The cartilage may occur in patients with polyostotic or monostotic disease, although the former is more common [12, 14, 16]. In those with polyostotic FD, the cartilage

may develop in only one or in several of the affected bones. The appellation "fibrocartilaginous dysplasia" (FCD) has been used for those cases in which the cartilage is abundant [1, 17, 18, 19]. In the latter situation, extensive deformity of the bone may develop and lead to significant therapeutic problems. Radiologically, FCD is similar to conventional FD with the addition, in most cases, of ring-like (annular) or scattered punctate to flocculent calcifications that may be so extensive as to simulate a primary cartilaginous lesion [1, 9, 10, 14, 18, 19, 20, 21, 22]. In polyostotic FD, the occurrence of lucent columns of uncalcified cartilage may produce a streak-like radiologic pattern that mimics that of enchondromatosis (Ollier's disease) [1, 21, 23]. The abundant cartilage has also occasionally led to a histologic misdiagnosis of chondrosarcoma arising in FD [13, 19, 24]. FCD has no relationship to the abnormality termed "focal fibrocartilaginous dysplasia" that involves the pes anserinus and causes tibia vara in young children [25].

The distinction between FCD and fibrocartilaginous mesenchymoma (FCM), another fibrous bone lesion that contains cartilage, is controversial, with some authors equating the two [1] while others view them as separate and distinct entities [26, 27]. We describe a patient followed for 18 years with progressive unilateral lower extremity deformity due to long-standing polyostotic FCD, review the English language literature on FCD, and discuss its distinction from FCM.

History

The patient, a 21-year-old white man, was first brought to medical attention at three years of age because of a slightly shortened right lower extremity and bowing deformity of the proximal right femur. A radiologic diagnosis of femoral enchondromatosis was made despite the absence of abnormalities in other bones at the time. The bowing deformity was considered mild and no surgical intervention was suggested. Over the next three to four years, radiologic evidence of disease in the ipsilateral hemipelvis developed. By age nine years, the femoral deformity had progressed to involve both its proximal end and the shaft (Fig. 1). Although not deformed, the tibia was also radiologically found to be entirely involved by what was again thought to be enchondromatosis (Fig. 2). However, tissue from a corrective osteotomy of the femoral shaft done at this time histologically showed FD without cartilage; the patient was now considered to have polyostotic FD. One year later, an osteotomy on the proximal right femur was done to correct progressive and significant varus deformity (Fig. 3). Despite the previous diagnosis of FD, the osteotomy tissue was histologically considered to be consistent with enchondromatosis. By age 11 years, there was slight enlargement of the distal right leg with varus deformity (Fig. 4), and a year later intramedullary nailing of the tibia was done in an effort to prevent further deformity. During this time, the plate-and-screw fixation hardware that had been placed in the right proximal femur was removed as it had not been effective in preventing progressive deformity. Although the patient now had a grossly deformed and functionless hip joint, he refused surgical therapy. Three years later, a 4.0 cm segment of the right tibia was excised and grossly found to be almost entirely replaced by cartilage. Histologic examination showed areas of FD containing mature hyaline cartilage, and a diagnosis of fibrochondrodysplasia was made. The enlargement of the distal tibia continued (Fig. 5) and by age 15 years the patient developed increasing pain in the leg with loss of foot and ankle function. During the next several years he had further functional and gait problems due to increasing right leg shortening. By age 18 years there was extensive right lower extremity deformity with marked enlargement of the distal tibia and severe bowing and bulbous deformity of the proximal femur (Fig. 6). Despite his symptoms, the patient refused further treat-

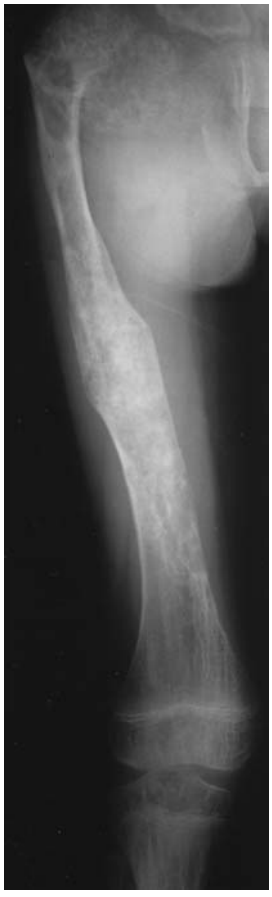

Fig. 1 Post-osteotomy view of the right femur at 9 years of age. Linear striations are present in the proximal tibia reminiscent of those seen in enchondromatosis

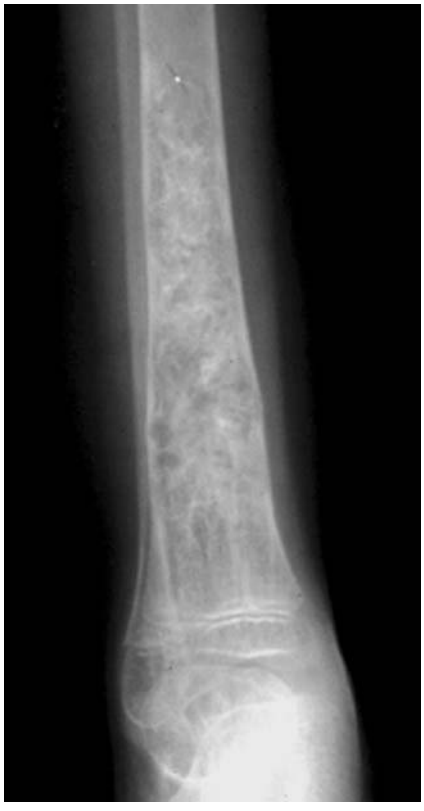

Fig. 2 Distal right tibia, at age 9 years, shows abundant calcification intermixed with areas of osteolysis. The distal metaphysis shows linear striations

ment and was not seen again until age 21 years, when he was admitted to our institution, for the first time, complaining of painful progressive enlargement of his right leg.

On examination, the distal right leg was deformed by a 12 cm mass that was hard and moderately tender, and was 30 cm shorter than the left leg. There was complete loss of motor function in the foot, although it was adequately perfused and had normal sensation. The patient had excellent motion of his knee, ranging from 0° to 120°, with good stability. The proximal thigh appeared bowed with an obvious varus deformity and a bulbous proximal femur. The hip was flail with essentially no joint function. The other extremities were normal, and there was no abnormal cutaneous pigmentation or symptoms of endocrine dysfunction. Cytogenetic studies for chromosomal alterations were not done. Roentgenograms showed marked expansion and distortion of the distal tibia with extensive calcifications. The distal diaphysis contained large lucent areas with endosteal scalloping (Fig. 7). Because of the extensive tibial deformity, loss of foot function, and marked leg length discrepancy, a below-knee amputation, with prosthetic placement, was done in August 1999, the patient refusing

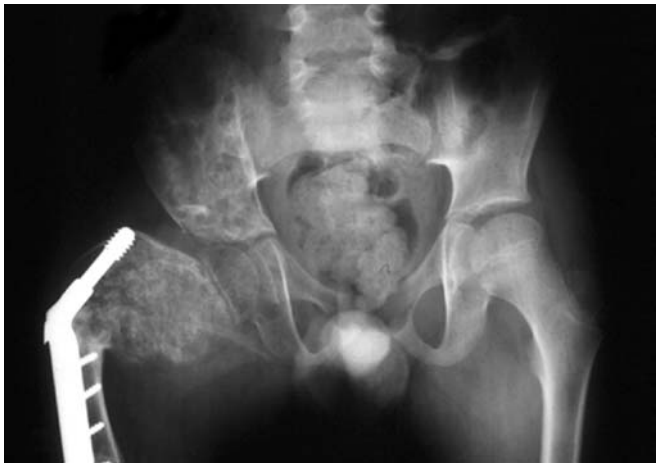

Fig. 3 Right proximal femur, at age 10 years, shows "shepherd's crook" varus deformity. The right ilium and ischium show abnormal trabeculation and calcification. The left half of the pelvis is not involved

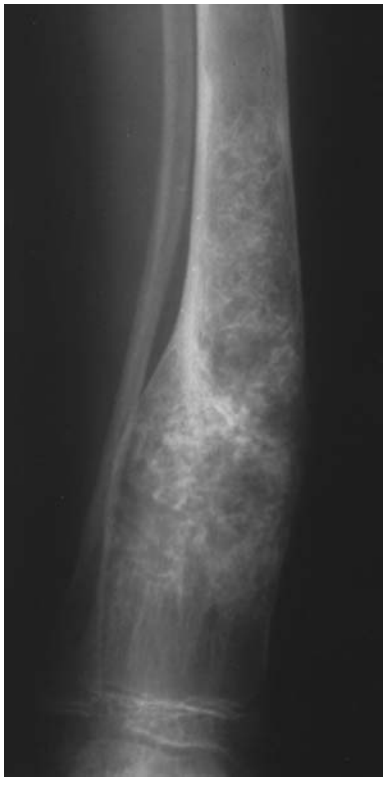

Fig. 4 View of the distal tibia, at age 11 years, shows progressive expansion of the diaphysis with dense punctate and annular calcifications (compare with Fig. 2). Note the preservation of linear striations in the metaphysis

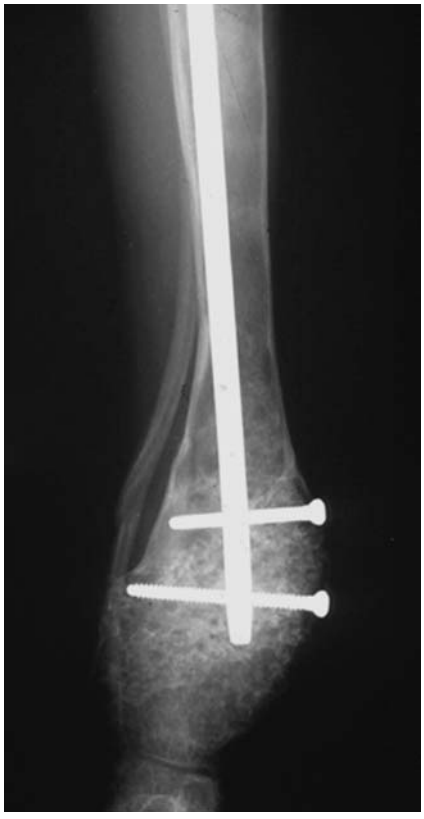

Fig. 5 View of distal right tibia, at age 15 years, shows bulbous expansion by a highly calcified mass. The cortex is markedly thinned, but appears intact. Linear striations are no longer present. The fibula is thinned with a twisted appearance

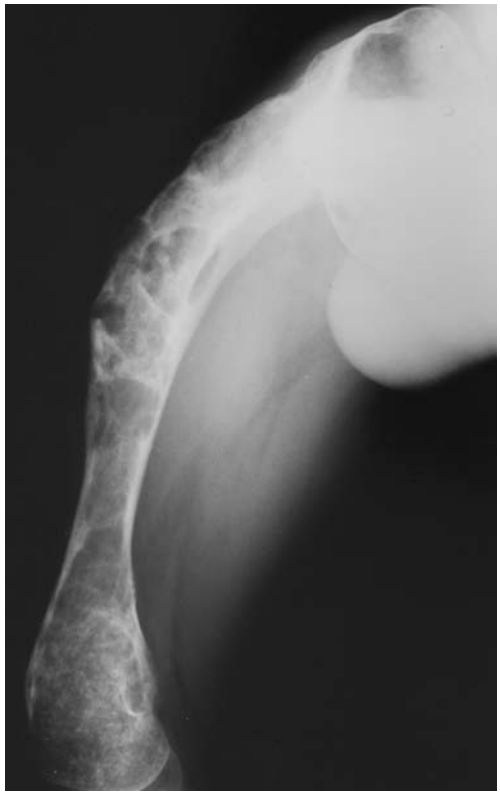

Fig. 6 Proximal femur, at age 19 years, shows expansion of the bone with bowing deformity. Both ends of the bone show bulbous expansion, most severe proximally. Punctate calcification is evident distally; the shaft shows large osteolytic foci associated with endosteal scalloping and cortical thinning

any operative therapy on his femur or hip joint. At six months postoperatively the patient was ambulatory, but was then lost to follow-up.

Pathology

The amputation specimen, from which the orthopedic hardware had been removed, showed the distal tibia to be extensively deformed by a round to angulated firm expansion that had produced pressure distortion and marked thinning of the adjacent fibula. The tibia, 26.7 cm in length, was bivalved in a coronal plane and showed a mass that filled almost the entire distal medulla up to the articular cartilage (Fig. 8). The mass was 10.5 cm wide and 14 cm long, the distal 10 cm of which was composed of variously sized and shaped nodules and conglomerate masses of blue-gray cartilage compacted into a jigsaw-like pattern (Fig. 9). The borders of the nodules were rimmed by yellow-white calcification; some contained myxoid centers having speckled yellow calcification. The proximal 4.0 cm of the mass consisted of dense, gritty, tan-white fibrous tissue that was continuous with similar tissue that extended 6.0 cm proximally into the non-expanded portion of the tibial shaft (Fig. 8A). The remainder of the proximal shaft contained brown-red marrow in which were a few scattered small islands of blue-gray cartilage (Fig. 8A). Transverse and longitudinal white fibrous hardware tracts ran through the specimen. The cortex of the entire tibia was markedly thinned, especially over the distal mass where it focally appeared to be absent with only periosteum present.

Histologically, the tibia contained zones of conventional FD with trabeculae of bone within a fibrous stroma (Fig. 10A). The trabeculae were irregularly shaped and consisted of immature (woven) bone lacking osteoblast rimming; no lamellar transformation was evident. The stroma was well vascularized with thin-walled blood vessels, and composed of benign-appearing spindle-shaped fibroblasts loosely arranged in a whorled, storiform pattern or dispersed within a dense collagenized matrix. Although in some regions the cells were more compacted, giving the stroma a more cellular appearance, there was no fascicular arrangement, nuclear atypia, abnormal mitotic activity or necrosis. Scattered clusters of macrophages with engulfed blood pigment were present

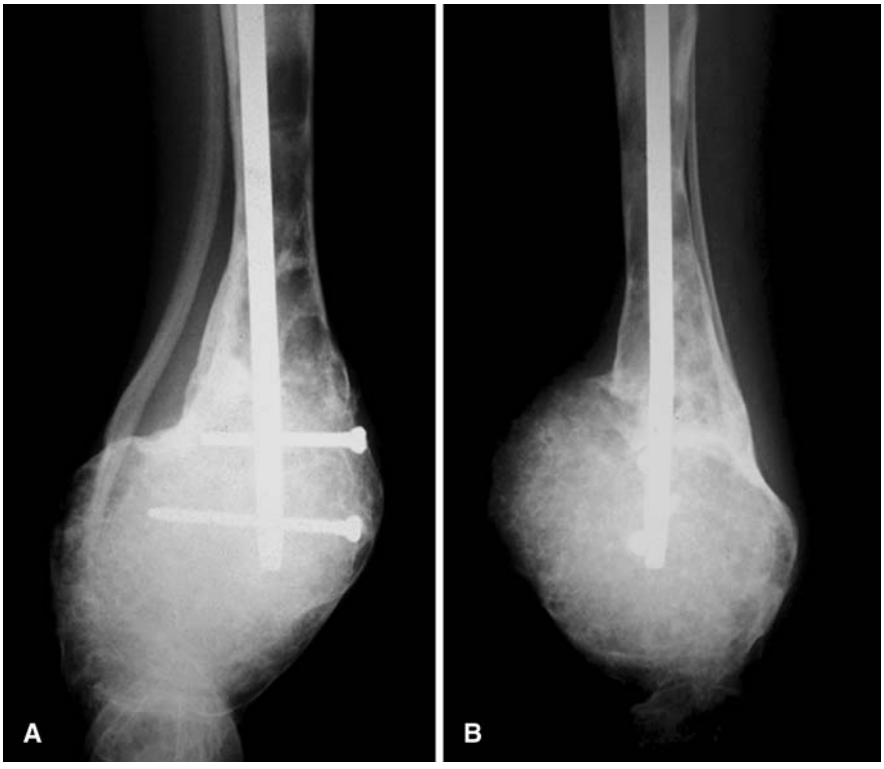

Fig. 7 Anterior (**A**) and lateral (**B**) views of the distal tibia, at age 21 years, show further marked distortion and expansion by a calcified lesion that has a shell-like margin. The distal diaphysis shows large lucencies with endosteal cortical scalloping

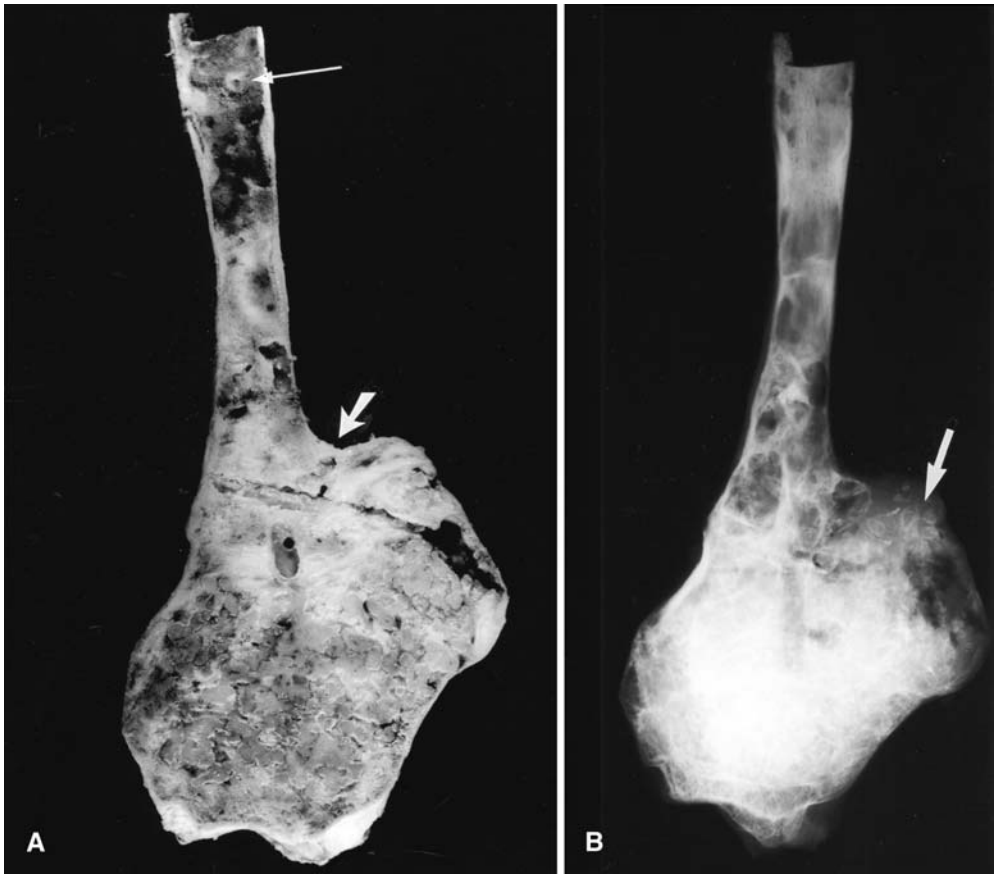

Fig. 8 **A** Amputation specimen shows cartilaginous replacement of the distal tibia with marked expansion and angulation. Cartilage nodules are also present in the proximal shaft (*thin arrow*). A white fibrous region of predominantly conventional fibrous dysplasia is seen in continuity with the distal cartilage (*thick arrow*). **B** Specimen roentgenogram shows both osteolytic and sclerotic zones associated with marked cortical thinning. Annular calcifications are well shown (*arrow*)

Fig. 9 Distal tibia is filled with irregularly sized and shaped cartilaginous nodules with peripheral white rims of calcification and bone. Within the proximal white fibrous area are longitudinal and transverse tracts from which orthopedic hardware has been removed

throughout the stroma. The areas of conventional FD were in continuity with similar regions that contained nodules of hyaline cartilage that varied from microscopic islands to large nodular masses. The nodules, the smaller of which could be seen to arise directly from the fibrous stroma (Fig. 10B), were scattered amongst the bone trabeculae. The larger nodules contained a peripheral rim of bone which, in most cases, had the same appearance as the woven bone in the adjacent stroma. In some instances, strand-like extensions from this rim of bone were in

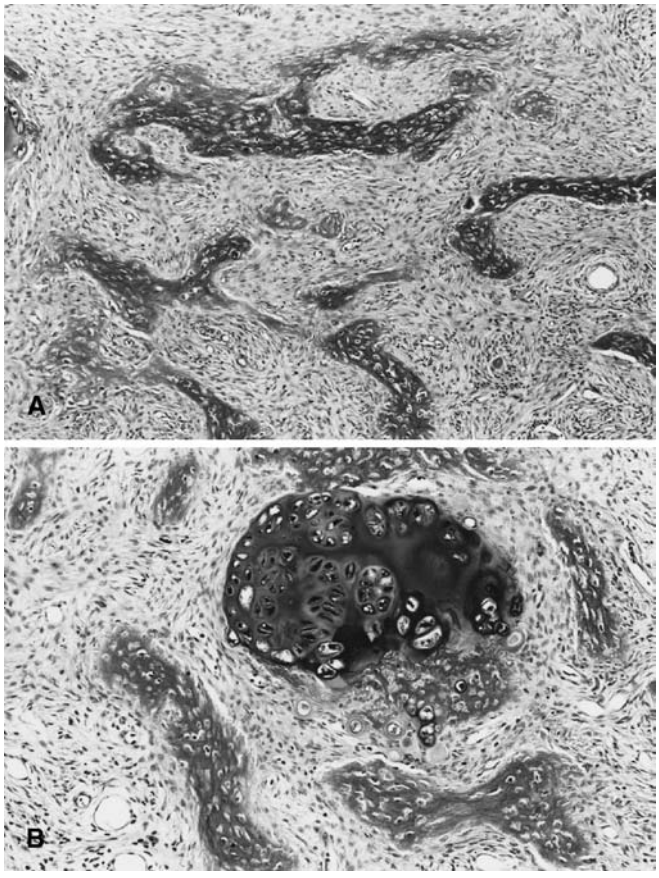

Fig. 10 A Histologic view of a conventional area of fibrous dysplasia within the tibia shows irregular trabeculae of woven bone within a uniform fibrous stroma. **B** Trabeculae of woven bone about an island of metaplastic hyaline cartilage arising from the stroma

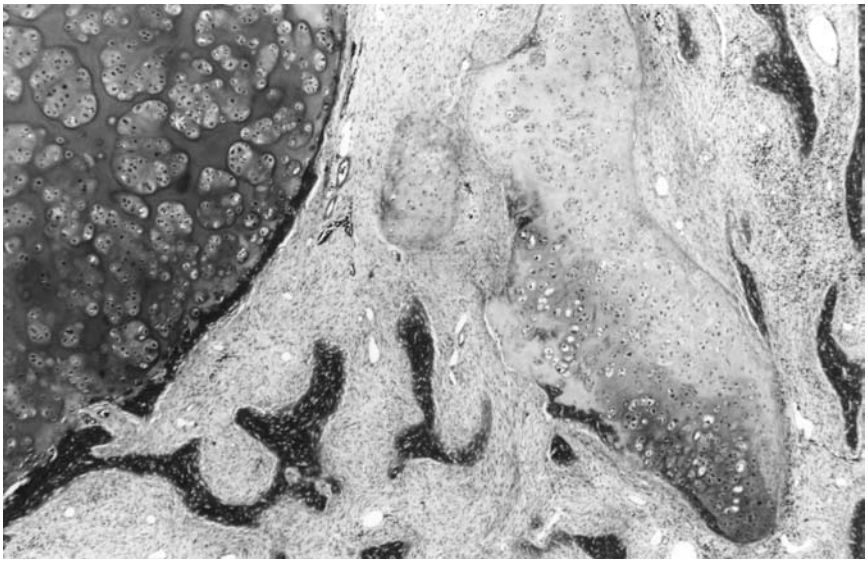

Fig. 11 Nodule of hyaline cartilage (*left*) contains a peripheral rim of immature woven bone that extends into the stroma to fuse with the stromal bone. Chondrocytes are small and in a cluster arrangement

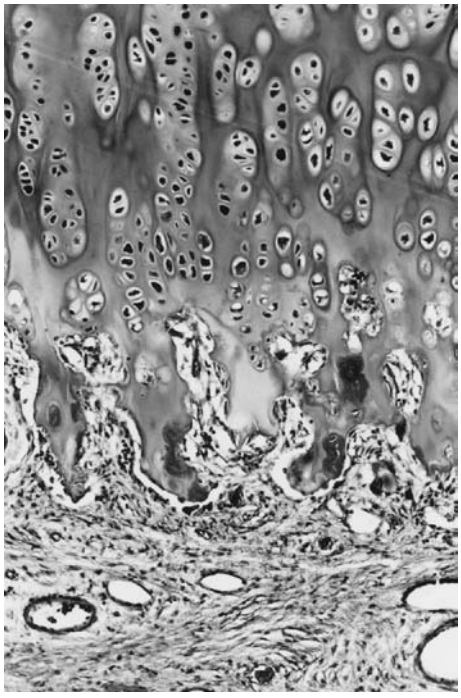

Fig. 12 Cartilage nodule with an epiphyseal-plate-like appearance. There is hypertrophy and columnation of the chondrocytes, invasion of the periphery by stromal capillaries, and focal ossification (*dark areas* at the bottom of the cartilage)

continuity with the stromal bone (Fig. 11). The chondrocytes were mostly arranged in small groups or nests and although many of their nuclei were enlarged, with visible chromatin, they lacked pleomorphism, individual cell necrosis, or mitotic activity (Fig. 11). Rarely, a cartilage nodule had a rim of lamellar bone that appeared to have developed by enchondral ossification. Some of the large nodules had a growth-plate-like pattern, with stromal capillaries, accompanied by osteoclast-type giant cells, invading the periphery of the nodules whose chondrocytes were enlarged and aligned roughly in columns, with the formation of bone by enchondral ossification (Fig. 12). This ossification was often incomplete, with trabeculae of partially ossified cartilage either uniting to form a sieve-like network immediately adjacent to the cartilage nodule, or extending deeply into the fibrous stroma in long strands (Fig. 13). The tibial shaft contained mainly areas of conventional FD with only occasional small nodules of cartilage, while the distal tibia had a predominance of cartilage with only a minimal amount of intervening fibrous stroma. The cortical bone was thin and in some areas absent, eroded by lesional tissue that abutted an intact periosteum; no soft tissue invasion was found. Histologic review of the tissue that had been previously removed from the right femur and tibia also showed FD with cartilage formation.

Discussion

Although most articles on FD acknowledge that it may contain cartilage, only a few provide data on its frequency. Harris et al. [12] reported cartilage in 5 of 37 polyostotic (14%) and in none of 13 monostotic cases. Van Horn et al. [16] found cartilage in 4 of 28 polyostotic (14%) and in 2 of 29 monostotic cases (7%), and Sanerkin and Watt [14] in 3 of 18 polyostotic (17%) and in 1 of 92 (1%) monostotic cases. In only the latter series was the extent or amount of cartilage indicated or implied. At times this cartilage is abundant, such cases being designated under the rubric of either "fibrochondrodys-

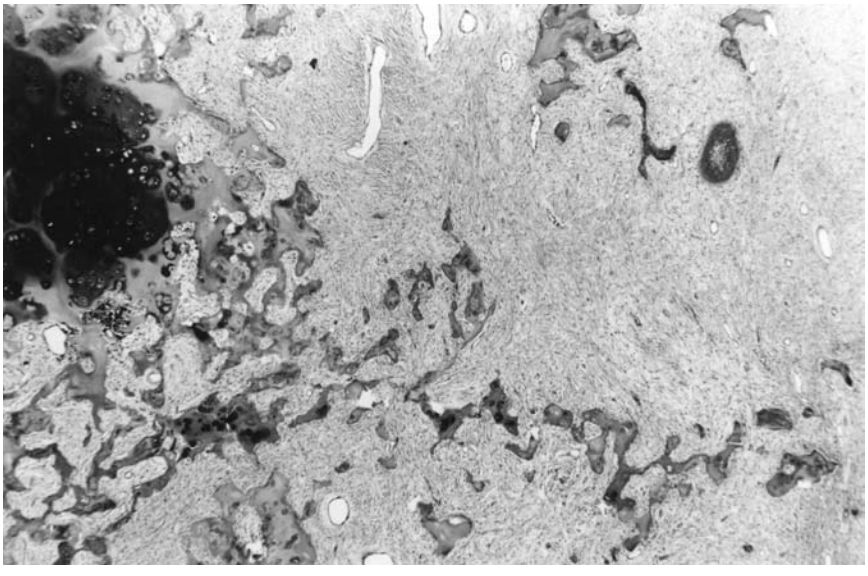

Fig. 13 Strands of partially ossified cartilage form a sieve-like network about a nodule of cartilage, and extend deeply into the stroma

plasia," a term introduced by Pelzmann et al. in 1980 [13] or, more frequently, "fibrocartilaginous dysplasia" [17, 18, 19].

In a review of the English language medical literature, we found 54 cases of FD in which cartilaginous differentiation was indicated [2, 3, 5, 10, 11, 13, 14, 18, 19, 20, 21, 22, 23, 26, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44]. Since no precise definition of FCD exists in terms of the amount of cartilage required for the diagnosis, we arbitrarily accepted all cases in which the presence of cartilage was either clearly evident radiologically, grossly present in a resected bone, or in which the histologic description indicated more than just a rarely encountered microscopic focus. Forty-one cases satisfied at least one of these criteria and were used for further analysis. Included in this group is the case reported by Sumner et al. [43] as fibrocartilaginous mesenchymoma but which, based on the histologic description, appears to best fit FCD, and the case reported by Clauser et al. [31] as combined FD and Ollier's disease.

In seven of the excluded cases only microscopic illustrations of the cartilage were provided, without an indication of its extent [12, 16, 45, 46, 47]; five other cases were reported as chondrosarcomas arising in FD, in four of which the possibility exists that the lesion was actually FCD [34, 48, 49, 50], while in the other it is probable, but not histologically proven, that the chondrosarcoma arose from an underlying FCD [33]; and in two cases reported by Stewart et al. [15], it was not possible for us to clearly define which of them could be classified as FCD.

The first complete report in the English language medical literature detailing the occurrence of cartilage in FD was by Telford in 1930 [44]. In this case, the cartilage was grossly evident in "considerable" masses. Review of the earlier literature is hampered by the multiplicity of diagnostic terms, and the various disparate lesions included under them, that were employed for FD prior to its histologic definition and designation by Lichtenstein in 1938 [36]; however, the cases reported by von Recklinghausen in 1891 and by Kuster in 1897 (briefly detailed by Knaggs [35]) that showed the presence of gross cartilage in osteitis fibrosa appear to be the earliest recorded examples of FCD. It is of historic interest that the patient described by McCune and Bruch [23] and one of those (case 3) detailed by Albright et al. [28], in their reports describing what is today known as the McCune-Albright syndrome, had extensive cartilage in their lesions consistent with FCD [37, 38, 51].

Detailed clinical information was provided in only 23 of the 41 patients [13, 14, 17, 18, 19, 23, 28, 30, 31, 32, 37, 38, 40, 43, 44, 51]. Illustrations of the radiologic images were available in 32, of the gross specimen in 11, and of the histology in 25 cases. In 33 patients with gender information, there were 20 males and 13 females. Patient ages (n=32) ranged from 3 to 66 years, with a mean of 18.3 years (median 14.5 years); only four patients were older than age 30 years. Male patients ranged from 3 to 53 years with a mean age of 17 years (median 14 years), and female patients from 6 to 66 years, with a mean age of 20.2 years (median 15 years).

The skeletal distribution of the FD was provided in 36 cases, with polyostotic disease in 22 (61%) and monostotic disease in 14 (39%). Six of the patients with polyostotic disease (27%) had associated McCune-Albright syndrome [21, 23, 28, 37, 38, 39, 40, 51]. The bone(s) involved with cartilage was provided in 40 of the 41 cases. This was a single bone in 32 cases, 14 of which were in patients with polyostotic FD, and multiple bones in eight. Within the single-bone group, the femur was involved in 24 cases, the tibia in three, the humerus in two, and the fibula, ilium and ischiopubic bone in one case each. In the multiple-bone group, a long bone was involved in all cases (femur 8, tibia 3, humerus 3, ulna 2, fibula 1, radius 1); the bones of the hands and feet in two cases each; the craniofacial bones in two; and the ilium, vertebrae and ribs in one case each. Among all patients, the femur was the most frequent bone involved, accounting for 32 cases (80%), in at least 24 of which (75%) the lesion was proximally located.

Details of the clinical presentation were available in 24 patients. Pain was the only symptom in three patients; pain and an associated soft tissue mass in one; pain with a bone deformity in three; and pain secondary to a pathologic fracture in one. A painless bone deformity, such as bowing, marked expansion and distortion, or limb shortening, was present in nine patients. A pathologic fracture, a mass, a limp, and nasal obstruction with eye proptosis were present in one patient each; three patients were asymptomatic.

Radiologically, FCD has been described as a lucent lesion, with well- to ill-defined borders [18, 19, 29, 34], usually containing scattered punctate to ring-like (annular) calcifications [1, 2, 3, 5, 9, 10, 13, 14, 17, 18, 19, 20, 21, 22, 29]. The calcification may be so extensive as to mimic an enchondroma or chondrosarcoma [1, 18, 19, 22]. In some cases, as in our patient, long lucent streak-like columns of uncalcified cartilage, extending from the growth plate into the metaphysis, are present, simulating the pattern of Ollier's disease [21, 23, 39]. The involved bone may be mildly to moderately expanded [2, 10, 19, 20] or distorted [3, 13, 17, 19, 20], extensively so in some cases, with marked expansion, bowing, shortening, and angulation, with evidence of prior healed fractures [14, 23, 30, 38, 44, 51]. In other cases, no significant bone distortion is present. Despite the extreme bone expansion that may occur in FCD, there is no soft tissue extension.

Histologically, FCD differs from conventional FD only by its additional component of cartilage, with the benign-appearing spindle cell stroma and irregularly shaped trabeculae of metaplastic woven bone found in both. The

round to oval stromal cells lack atypia and are arranged in a storiform pattern or widely separated within a densely collagenized stroma [19]; a herringbone or fascicular arrangement is not present. Small, irregular islands of metaplastic chondroid and cartilage, arising from the fibrous stroma, are intermixed with larger nodules of hyaline cartilage that are sharply circumscribed and usually uniformly round [3, 9, 19]. The periphery of these nodules is frequently calcified [2, 14, 34, 36, 37, 51] and rimmed by a layer of woven bone or, less frequently, lamellar bone [3, 14, 38, 51], the latter developing by enchondral ossification [2, 13, 14, 18, 19, 37, 46, 51]. The woven bone may extend from the cartilage to merge with that in the adjacent stroma [19, 38]. In cases in which the epiphyseal growth plate is still evident, it may be markedly irregular, with seams of partially calcified and ossified cartilage extending from it in long columns into the metaphysis [21, 38, 39]. The cartilage chondrocytes usually lack atypia and are either uniformly distributed or loosely arranged in small clusters. At times, however, the nodules may be hypercellular, with binucleated cells mixed with cells having a degree of nuclear atypia as found in low-grade chondrosarcoma [1, 13, 14, 17, 19, 46]. Some cases of FCD contain fragments of cartilage that resemble the epiphyseal growth plate, with hypertrophied chondrocytes arranged in columns; irregular borders invaded by stromal capillaries and osteoclast-type giant cells; and calcification of the cartilage with the formation of lamellar bone rimmed by osteoblasts [1, 3, 5, 9, 14, 19, 29, 43, 51]. This enchondral bone formation may be incomplete, with seams of interlacing, partially ossified cartilage extending into the stroma.

The origin of the cartilage in FCD is controversial, some believing that it derives from offshoots or rests of the epiphyseal plate that proliferate and grow [3, 5, 14, 21, 34, 39]; others that it arises by direct stromal metaplasia [2, 18, 28, 36, 44]; or that it develops from both processes [37]. The rare occurrence of FCD in the calvarium and vertebral body [28, 31, 38, 51], sites lacking an epiphyseal plate, would argue against the latter as the site of origin, at least in some cases. However, the irregularly bordered epiphyseal plates in some cases of FCD [21, 39], with long columns of cartilage streaming into the adjacent metaphysis, would support this as a site of origin for some of the cartilage. In our patient, foci of metaplastic cartilage arising directly from the stroma were present.

Conventional FD and FCD share some clinical similarities, and some notable differences. FCD occurs slightly more commonly in male than female patients (1.5:1) than does conventional FD, in which female patients are either more often involved [3, 8, 9] or equally involved [5, 7]. Similar to FCD patients, the majority of FD patients are younger than age 30 years [1, 3, 5, 8]. The femur is the commonest site for FCD, and is one of the most common sites for conventional FD [1, 3, 5, 6, 7, 8], the proximal femur being most often involved in both [1, 3, 5, 6, 7, 8]. However, FD frequently involves the craniofacial bones and ribs [1, 3, 5, 6, 7, 9], sites that have rarely been affected by FCD. We found only two examples of FCD involving the craniofacial bones [28, 31, 38], and only one case, with multiple bone involvement, where cartilage at the costochondral junction extended into the body of the ribs [38]. Significantly, while monostotic disease accounts for 70% to 90% of all conventional cases of FD [5, 6, 7, 8, 9], more than 60% of the cases of FCD are in patients with polyostotic FD. The percentage of FCD cases with associated McCune-Albright syndrome (27%) is also greater than the 3% incidence that occurs with conventional FD [3, 5, 6, 34]; however, this may be a statistical artifact due to the small number of FCD cases reported.

The histologic differential diagnosis in FCD is rather restricted and includes enchondroma, chondrosarcoma, chest wall hamartoma, and fibrocartilaginous mesenchymoma.

Small biopsy tissue may contain only the cartilage component of the lesion and, given the radiologic presence of calcification, result in a diagnosis of enchondroma or enchondromatosis. However, epiphyseal-plate-like areas and cartilage nodules rimmed by woven bone are not features of enchondroma.

The extensive amount of cartilage in FCD, combined with the occasional occurrence of chondrocyte nuclear atypia, may, as pointed out by others [1, 13, 18, 19, 46], cause confusion with chondrosarcoma (CS). Although rare, CS has developed in cases of FD in which FCD had not been previously diagnosed or radiologically apparent [24, 52], as well as at sites of underlying FCD [32, 33, 40]. Supporting a benign diagnosis in our patient, and in other cases of FCD, is the absence of soft tissue invasion, which would be highly unusual for CS given the size and extent of the lesion. In addition, the presence of peripheral enchondral ossification in the cartilage nodules, the foci of growth-plate-like cartilage, and the metaplastic cartilage in the spindle cell stroma are not features of conventional CS. Although the presence of cartilage nodules sharply juxtaposed to a spindle cell stroma raises the possibility of dedifferentiated CS, the stroma of the latter, unlike that in FCD, has the appearance of a high-grade sarcoma, with pleomorphic cells having marked nuclear atypia and abnormal mitotic figures.

The epiphyseal-plate-like cartilage found in FCD also occurs in chest wall mesenchymal hamartoma and fibrocartilaginous mesenchymoma. The former is easily distinguished from FCD by its almost exclusive occurrence in the ribs and chest wall soft tissue of infants; by its histologic component of areas resembling aneurysmal bone cyst; and the absence of FD-like foci [53, 54].

Fibrocartilaginous mesenchymoma (FCM) is the lesion most easily confused with FCD, the two conditions sharing overlapping clinical, radiologic and histopatho-

logic features such that some authors equate the two [1]. Although FCM was initially described as a low-grade malignancy [55], it was subsequently considered to be a benign but locally aggressive lesion with a relatively high local recurrence rate [5]. FCM is rare—we found only 16 cases in the English language medical literature [26, 55, 56, 57, 58]. Patients with FCM, like most of those with FCD, are young, 81% being younger than age 20 years (range 9 to 26 years; mean 14.8 years.) As in FCD, a long bone is most frequently involved (10 cases), but unlike FCD where the femur is the leading site, in FCM the fibula has been most commonly involved, accounting for four cases, with the femur involved in only one case. Radiologically, FCM and FCD may be indistinguishable, as both are osteolytic and, in most cases, contain punctate or ring-like calcifications [26, 55, 56, 58]. Although FCM causes mild to moderate bone expansion, it does not produce the gross distortion that may occur in FCD. In contrast to FCD where, despite any massive expansion of the bone or cortical erosions, there is no soft tissue involvement, FCM may destroy the cortex and extend into the soft tissue [26, 55, 58]. Also unlike what may occur in FCD, no case of FCM involving multiple bones has been reported. Histologically, FCM consists of islands of hyaline cartilage, or chondroid, that reside within a compact, fascicular, spindle cell stroma that may or may not be hypercellular [26, 55, 56, 57, 58]. The spindle cells may demonstrate mild nuclear atypia and hyperchromasia [26, 55]. In contrast, the stroma of FCD is less cellular, and its cells lack nuclear atypia or hyperchromasia. Some authors emphasize the elongated slender shape of the stromal cells in FCM versus the short and stubby appearance of those in FCD [26, 27]. In both conditions, the hyaline cartilage exists as well-circumscribed round to irregular nodules with calcified or ossified borders [26, 55, 56, 58] or in the form of islands that have an epiphyseal-plate-like appearance with enchondral ossification [26, 55, 56, 57, 58]. Although bone production occurs in FCM, it is in the form of trabeculae, formed by enchondral ossification at the periphery of the cartilage masses, that are rimmed by osteoblasts, unlike the trabeculae of immature metaplastic bone, lacking osteoblasts, characteristic of FD. Based on the above differences, it is our view that FCD and FCM can be distinguished, and we agree with those who believe them to be separate entities [26, 27].

Although the terms “fibrocartilaginous dysplasia” and “fibrochondrodysplasia” have been applied to cases of FD containing an “abundant” amount of cartilage [1, 13, 17, 18, 19], we were unable to find in any publication an indication of how much cartilage must be present for this appellation to be applied. A variety of adjectives have been used defining the amount of cartilage present, including “large” [9, 13, 19, 21, 22, 28, 30],”extensive” [1, 5, 14, 18], “prominent” [18, 19, 59], “abundant” [8, 18, 47], “considerable” [8, 23, 30], “massive” [1, 3, 5, 19, 20], “dominant” [9], “conspicuous” [47] and “striking” [2], all without any specific quantification. The amount or size of the cartilage that may occur in “conventional” FD is frequently described as being small, less than 1.0 cm, this figure apparently derived from the 1942 paper by Lichtenstein and Jaffe [2], based on an analysis of only 23 cases at the time, and repeated by subsequent authors without further supporting data. What term, if any, should be used to designate those cases with only a “minimal” amount of cartilage has never been addressed. It appears to us that the cartilage, regardless of its extent, is produced in the same manner in all of these cases, differing only in extent, and logic would dictate that the same diagnostic label be applied to all such cases. Indeed, in their classic paper on FD, Lichtenstein and Jaffe [2] recognized that cartilage was “an integral part of the dysplastic process,” but did not incorporate this concept into its name only because it would have made it too cumbersome. We would prefer not to use the terms fibrochondrodysplasia or fibrocartilaginous dysplasia as they imply that the lesion is separate and distinct from FD, when in reality it is simply a variant with an exaggeration of the cartilaginous component of the dysplastic process. This is perhaps best exemplified by the report by Pelzmann et al. in which the diagnosis was given as “polyostotic fibrous dysplasia and fibrochondrodysplasia,” as if the latter were a separate process [13], and that by Drolshagen et al. [17] who state that FCD is a “complication” of FD. We prefer to designate all these cases as fibrous dysplasia with cartilaginous differentiation, with the option of an added adjective indicating its extent, as done by Ishida and Dorfman [19]. The elimination of FCD as a label for these cases would also avoid any confusion with the process involving the pes anserinus that causes tibia vara in childhood and which carries a similar label [25].

Some authors have emphasized that the presence of cartilage in FD is often an indicator of future progressive bone deformity, especially when the cartilage develops in young patients [14, 60]. That this has occurred is well documented [13, 14, 17, 23, 28, 30, 38, 51], and was clearly the case in our patient. However, how much the existence of cartilage contributes to the severity of the bone abnormalities beyond that which may occur in conventional FD without cartilage is unclear, as there are cases, including those among adults, in which no major bone distortion has occurred even in some cases described as having a “massive” cartilaginous component [2, 5, 10, 14, 18, 19, 21, 22, 39, 43]. In our own patient, the massive quantity of cartilage had clearly contributed to the marked expansion and distortion of the involved bones to such a degree that an amputation was required.

In summary, fibrous dysplasia may occasionally contain cartilage, the amount of which is quite variable. Cases in which the cartilage is radiologically, grossly or histologically abundant usually occur in patients less than

30 years of age and, most commonly, in those with polyostotic disease where the cartilage may be present in only one or in several of the bones affected by the fibrous dysplasia. The femur is involved in 80% of all cases, most often in its proximal aspect. In contrast to conventional fibrous dysplasia, the ribs and craniofacial bones are rarely involved. When the cartilage is extensive, the radiologic pattern may suggest a primary cartilaginous lesion such as Ollier's disease or chondrosarcoma. We suggest that the terms fibrocartilaginous dysplasia and fibrochondrodysplasia, which have been used to designate these cases, be avoided as they imply that the lesion is a distinct entity separate from conventional FD when it is only a clinicopathologic variant. Although their clinical, radiologic and histologic features may overlap, we believe that fibrous dysplasia with cartilaginous differentiation can and should be distinguished from fibrocartilaginous mesenchymoma, a locally aggressive fibrous lesion of bone that also contains cartilage.

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