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Distal Femoral Cortical Defects, Irregularities, and Excavations

A Critical Review of the Literature with the Addition of Histologic and Paleopathologic Data[1]

A review of available radiographic and pathologic material revealed evidence that two distinct anatomical variations may be found on the posteromedial aspect of the distal femur. One, the femoral cortical irregularity, is a common finding on clinical radiographs, shows a definite predilection for children and adolescents, and is closely located to the site of attachment of tendinous fibers of the adductor magnus muscle. It is almost certainly related to stress, and can be associated with a degree of periosteal proliferation that simulates malignancy. In a study of prehistoric adult femoral specimens, the second lesion, the femoral cortical excavation, was a frequent finding. However, it appears to be less common in clinical radiology. It occurs at the osseous site of attachment of the medial head of the gastrocnemius, which supports a stress-related pathogenesis. Its relationship to fibrous cortical defects is not clear.

Index terms: Femur • (Femur, anatomical detail, 4[44].920) • Femur, injuries • (Femur, normal variant, 4[44].130)

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CYSTIC lesions and cortical irregularities in the posterior aspect of the distal femur have been repeatedly described in the literature (TABLE I). The initial reports of Sontag and Pyle in 1941 (1), Kimmelstiel and Rapp in 1951 (2), and Allen in 1953 (3) were soon followed by a host of additional articles (4-12) and sections of books (13, 14) in which the lesions were further delineated. This intense interest was stimulated by the apparent frequency of the abnormalities and by the fact that they might be misinterpreted as being indicative of malignant neoplasm. A review of prior reports indicates that a variety of terms has been applied to these cystic and proliferative changes, including fibrous cortical defects; subperiosteal, periosteal, and cortical desmoids; and (benign) metaphyseal and avulsive cortical irregularities. An understanding of these femoral abnormalities requires a critical survey of previous pertinent literature.

LITERATURE REVIEW

In his classic work in 1953 (15), Caffey summarized the clinical, radiologic, and pathologic characteristics of fibrous cortical (fibrocortical) defects of tubular bones. He indicated the major radiographic alterations: metaphyseal localization; variable size; and a sharply demarcated, radiolucent oval lesion with its long axis parallel to the long axis of the bone. In the distal femur, the most frequent site of involvement, the lesions were most common on the dorsal and medial cortical walls, and were rarely found on the lateral walls. The clinical characteristics of cortical defects in the distal femur, as well as in other skeletal sites, included predominance in children (in whom defects may be apparent in approximately 35% of cases) and in boys, frequent bilaterality, a decreasing incidence in individuals who are 13 or 14 years of age, and an occasional persistence to adult life. Caffey's experience regarding the frequency of such lesions in varying age groups was generally consistent with prior reports by Sontag and Pyle (1) and Hatcher (16), although minor differences existed among these reports. Caffey (15) maintained that cortical defects never appeared for the first time in adult life, so that such defects in adults represented persistence of juvenile lesions. He also emphasized the shaftward shifting of those cortical defects that persisted over long periods of time, and speculated that the earliest phase in the formation of the cortical defect might consist of an area of subperiosteal abrasion in the superficial external layer of the cortex, which produces an irregular, poorly defined, moth-eaten radiolucency. In this manner, the characteristics of cystic lesions (referred to as fibrocortical defects) and irregular cortical excrescences (referred to as subperiosteal desmoids and avulsive cortical irregularities) were described as representative of the same basic lesion at different stages

TABLE I: Historical Review

Reference	Name	Age/Sex/ Distribution	Roentgen Appearance	Histologic Findings	Pathogenesis	Miscellaneous
Sontag & Pyle (1941) (1)	Metaphyseal "cyst"	Children, boys > girls 2–9 yrs. of age Unilateral or bilateral	1–3 cm, round or oval lucency, medial condyle, ± surrounding sclerosis	—	Cartilaginous rests with osteoclastosis	Asymptomatic, self-limited with universal spontaneous disappearance Rarely disappear and recur 53% of boys; 22% of girls
Kimmelstiel & Rapp (1951) (2)	Periosteal desmoid	Boys 1st and 2nd decades of life	Subperiosteal cortical erosion with hyperostosis	Cortical defect filled with fibrous tissue Cartilage and osteoid material Osteoclastosis and osteoblastosis	Unknown; Unrelated to trauma ± true tumor	Histologically similar to desmoid of striated muscle
Allen (1953) (3)	Variation of diaphyseal development	Boys and girls 2nd decade of life	Cortical irregularity with soft-tissue mass	Periosteal thickening and calcification	Developmental variation Relationship to perforating nutrient vessels	Simulates malignancy
Kohler & Zimmer (1956)	—	—	Cortical erosion and periostitis	—	Related to attachment of plantaris and gastrocnemius muscles	—
Simon (1968) (4)	Metaphyseal irregularity	Boys > girls 1st and 2nd decades of life Left side > right side	Elongated cortical irregularity and roughening or spiculation Abnormality of tubulation	—	Developmental variation	May remain unchanged or disappear Close to insertion of some fibers of adductor magnus 11% of boys; 4% of girls
Caffey & Silverman (1967) (13)	—	Adolescents	Cortical thickening	—	Normal variant	—
Johnson *et al.* (1968) (5)	Cortical desmoid	Adolescents Boys > girls	Shallow surface excavation with sclerotic border	Proliferating subperiosteal tissue Osteoclastosis	Minor avulsions at sites of tendon insertions	Asymptomatic Seen in active patients
Brower *et al.* (1971) (6)	Cortical irregularity	1st and second decades of life	Subperiosteal bone formation Cortical irregularity without lucency	Periosteal thickening Fibrous tissue proliferation Osteoclastosis Identical to fibrocortical defect	Healing phase of fibrocortical defect	Asymptomatic
Bufkin (1971) (8)	Avulsive cortical irregularity	1st and second decades of life	Shallow, concave osteolytic lesion Cortical fragmentation and roughening Surrounding sclerosis	Refers to Kimmelstiel's findings	Traumatic Stress with cortical avulsion at adductor insertion site	Occurs at site of insertion of transverse fibers of adductor magnus aponeurosis
Young *et al.* (1972) (7)	Benign cortical irregularity	1st and second decades of life Boys and girls Left side = right side	Cortical loss and irregularity Soft-tissue changes	Cartilage layer adjacent to cancellous bone Vascular fibroblastic material Identical to flat osteochondroma or avulsive injury	Unknown	5% of boys; 8% of girls May decrease in size or disappear Occasionally on lateral side of femur
Barnes & Gwinn (1974) (9)	Cortical irregularity	1st and 2nd decades of life	Cortical break and irregularity or spiculation	—	Stress at site of attachment of aponeurotic sheath of adductor magnus muscle	Smooth irregularity at same site occasionally seen in adults

Table I: Historical Review *Continued*

Reference	Name	Age/Sex/ Distribution	Roentgen Appearance	Histologic Findings	Pathogenesis	Miscellaneous
Kreis & Hensinger (1977) (11)	Cortical irregularity	Adolescents	Cortical irregularity and proliferation	Normal	Supports report of Barnes and Gwinn	—
Kirkpatrick & Wilkinson (1978) (12)	Post-traumatic fibrous tissue or periosteal desmoid	Adolescents	Long segment of cortical irregularity and proliferation	Periostitis with acellular fibrous tissue proliferation	Stress at site of attachment of adductor magnus	Lesion may be more prominent in patients who are unusually active
Dunham *et al.* (1980) (10)	Developmental defect	1st and 2nd decades of life Boys > girls	Ill-defined lucent lesion with cortical thickening and periostitis	Dense fibrous tissue with mild inflammation Bony spicules with osteoblasts and giant cells	Stress at site of attachment of adductor magnus	May persist into adulthood Asymptomatic

of development and healing. Caffey's description of the pathologic abnormalities of fibrocortical defects, which was based principally on a review of prior reports and borrowed microscopic material, included localized intimal fibrous hyperplasia of the periosteum and hemorrhage, indicating, he believed, a hyperplastic local reaction to trauma. This theory of traumatic pathogenesis was supported by evidence that, in the distal femoral shaft, the position of the medial cortical defect corresponded to the site of attachment of the medial head of the gastrocnemius.

In 1968, Simon (4) described a common metaphyseal irregularity of the distal end of the femur occurring in the first and second decades of life, which he believed was related to a developmental anomaly. He noted the prior report of Allen (3), but failed to cite the report of Kimmelstiel and Rapp (2), both of which had apparently described this same lesion. In the same year, Johnson *et al.* (5) described the experience of the Armed Forces Institute of Pathology with 75 cases of the lesion, using the term cortical desmoid and emphasizing its occurrence along the medial extension of the linea aspera in asymptomatic active adolescent boys. The cortical erosion was lined with osteoclasts and filled with proliferating subperiosteal connective tissue and small fragments of resorbing bone. Johnson *et al.* believed that the lesion was radiographically and histologically different from the cortical defect.

Brower *et al.* in 1971 (6) further defined the cortical irregularity in a study of an amputation specimen in a 14-year-old boy with a known osteogenic sarcoma. They noted that the proliferative lesion lay along the medial distal extension of the linea aspera in an area that possessed no muscular or ligamentous attachment. Histologic evaluation revealed fibrous tissue proliferation continuous with a thickened periosteum and associated with marked osteoclastic activity, an appearance identical to that of a fibrocortical defect. Their conclusion reaffirmed Caffey's belief that the irregularity represented a healing phase of the typical fibrous cortical defect. In the same year, Bufkin (8) described an identical lesion, terming it the avulsive cortical irregularity. Although he maintained that this abnormality differed from a fibrocortical defect, occurring at the site of insertion of a portion of the transverse fibers of the adductor magnus aponeurosis, no anatomic evidence of this fact was presented. The histologic data presented by Bufkin were supplied by Kimmelstiel, and once again documented thickened periosteum, a fibrous tissue mass, resorbing pieces of bone, and osteoclastosis.

The report in 1972 by Young *et al.* (7) of similar distal femoral cortical irregularities included biopsy specimens in two patients that revealed cellular, edematous, and thickened periosteum; fibroblastic tissue; and cartilage. These findings were interpreted as being identical to those of an osteochondroma. These investigators reiterated the fact that the site of femoral abnormality did not correspond to a specific tendon attachment, although no alternative pathogenesis was offered.

An article by Barnes and Gwinn in 1974 (9) served as a rebuttal of previous descriptions of cortical irregularities that had stated that no connective tissue structures attached to the femur at the typical site of the lesion. Based upon dissections of seven femoral specimens in adults and children, they stressed the constant occurrence of an aponeurosis from the extensor portion of the adductor magnus muscle that ran in a horizontal and medial direction to attach to the medial supracondylar ridge. Unfortunately, none of their dissected specimens revealed the cortical irregularity, so their conclusion was based upon the similarity of the site of aponeurotic attachment on the anatomic cadaveric specimens with that of the lesion on radiographic examination in patients.

In the last few years, additional articles have described the cortical irregularity, emphasizing its occurrence in active individuals (10, 12) and its similarity to malignancy (11).

Certain facts emerge from this detailed review of the literature. Although some early reports grouped together cystic and proliferative lesions of the distal posterior femoral metaphysis, and, in fact, considered them to represent a single entity observed in different stages of development and healing (6, 15), subsequent investigators have stressed the different clinical and radiographic features of the typical cystic cortical lesion and the proliferative cortical irregularity. The former lesion is considered a fibrocortical defect, predominating in children and young adolescents, and presenting as a cortical lucency or excavation. It occurs lateral to the medial supracondylar ridge of the femur, analogous to cortical defects at other skeletal sites. The latter may be observed in slightly older patients, occurs along the medial supracondylar ridge, and appears as cortical spiculation or irregularity that may simulate neoplasm. Disagreement

Figure 1

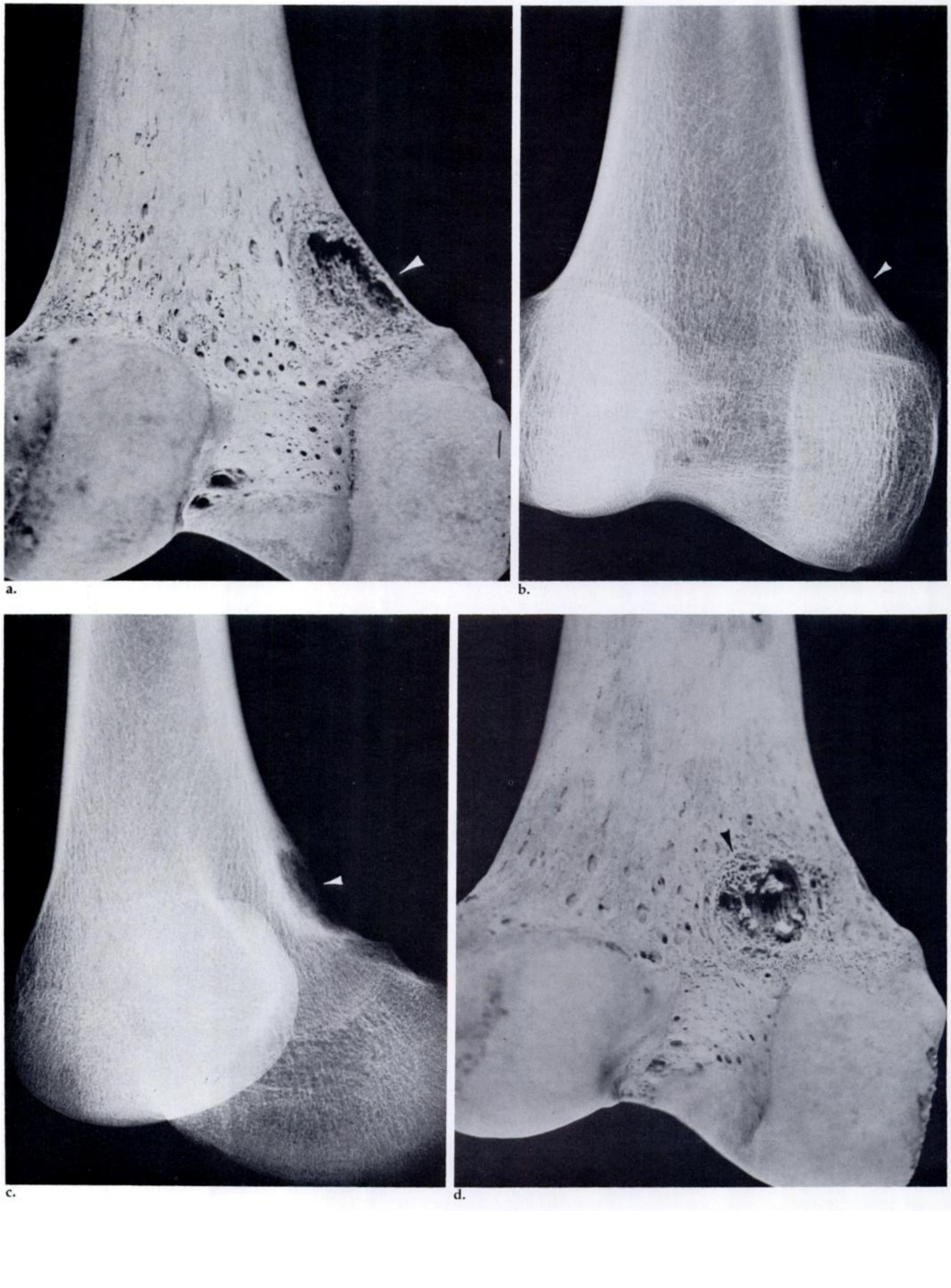
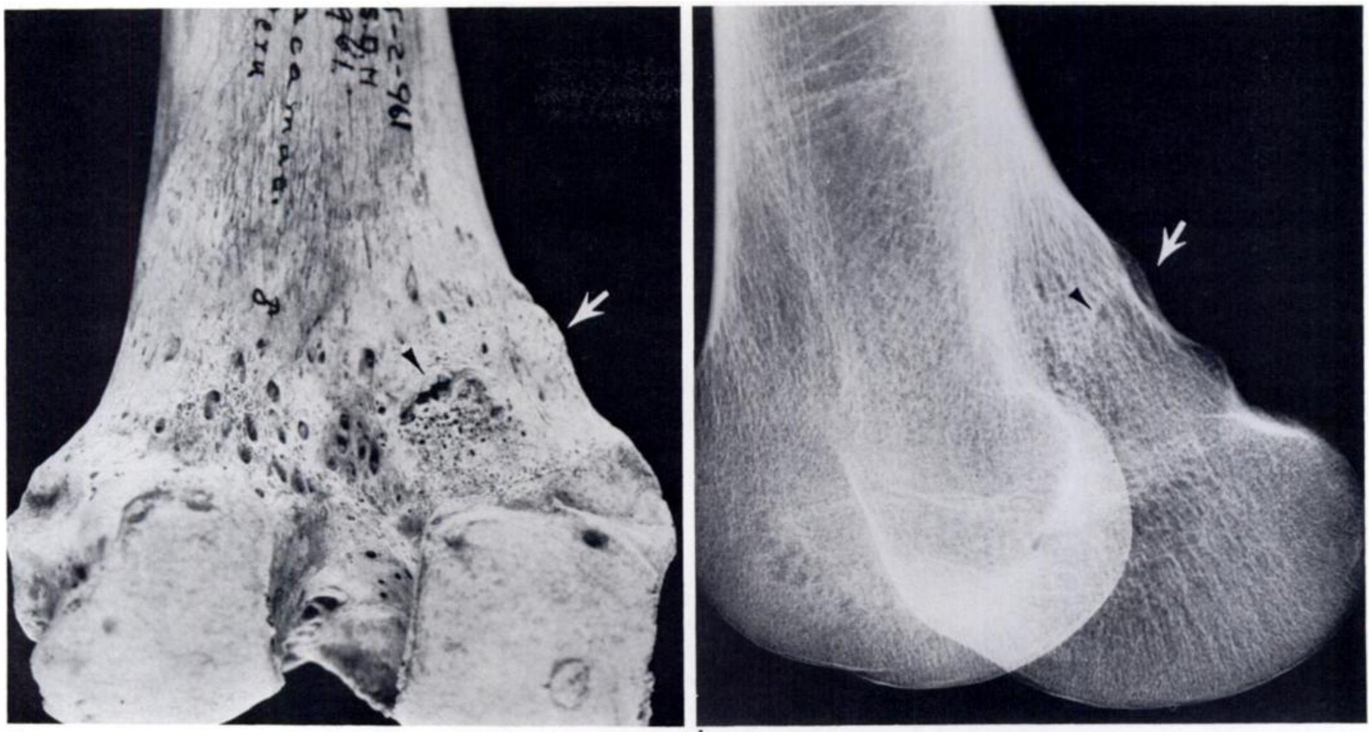


Figure 2



a. b.

a and **b**. A shallow excavation (arrowheads) is observed on the photograph of the posterior surface of the distal femur (**a**) and the oblique radiograph (**b**). Accompanying prominence of the supracondylar ridge is evident (arrows). (Prehistoric, adult male specimen, obtained from Pachacamac, Peru, left femur, associated osteoarthritis of the knee and hip, torsion of femur.)

still exists, however, with regard to whether these two radiographically distinct lesions are variants of the same entity (*i.e.*, fibrocortical defect), and if either or both are the result of abnormal stress. It is our belief that two distinct abnormalities exist in the distal femur, one cystic and one proliferative in nature, and that both are traumatic in etiology. This belief is based upon a study of radiographic and pathologic characteristics of the distal femoral cortical irregularity (*i.e.*, avulsive cortical irregularity, periosteal desmoid), and a unique opportunity to examine prehistoric femoral specimens in which distal femoral cortical cystic lesions (*i.e.*, cortical excavations) were apparent.

MATERIAL AND METHODS

A collection of over 1,000 osseous specimens at the San Diego Museum of Man was examined (18). This collection was derived from an expedition to Peru in 1913 by Dr. Ales Hrdlicka, curator of the Division of Physical Anthropology of the United States National Museum in Washington, DC. Of approximately 140 prehistoric femoral specimens, most of which were from adult cadavers, examination disclosed 21 (15%) in which cortical porosity or excavation was evident in the posteromedial aspect of the distal femur. These specimens were then radiographed and photographed in an attempt to define the nature and the roentgen appearance of the abnormalities, hereafter called distal femoral cortical excavations.

Six fresh adult cadaveric knees were frozen and, with a band saw, sectioned in coronal, sagittal, or transverse planes. The sections were examined, radiographed, and photographed in an attempt to define the muscular and tendinous anatomy of the posteromedial aspect of the distal femur. No distal femoral lesions were present in these specimens.

Radiographs of ten representative distal femoral periosteal and cortical proliferative lesions, hereafter called proliferative cortical irregularities, in children, adolescents, and adults were reviewed to facilitate comparison of the distal femoral cortical excavation and the proliferative cortical irregularity.

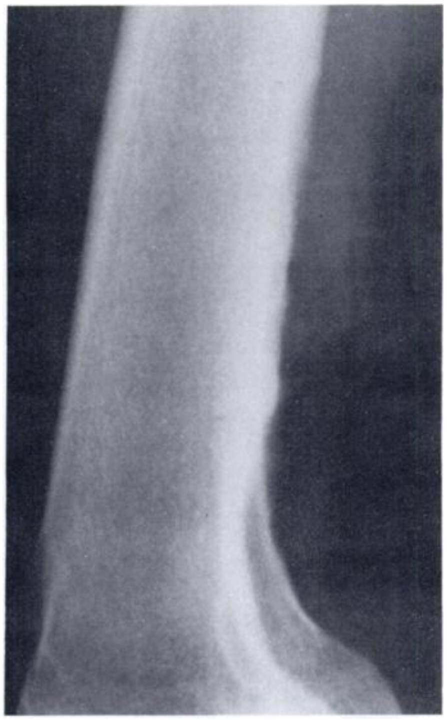
An intact specimen of a typical proliferative cortical irregularity was examined. This lesion was an incidental finding in a patient who required amputation for a more proximal femoral malignancy. Dissection, freezing, tissue sectioning, radiography, photography, and histologic evaluation were accomplished in this specimen.

←

a-c. Distal femoral cortical excavation. A photograph of the posterior surface (**a**) of the distal femur and accompanying frontal (**b**) and oblique (**c**) radiographs reveal the typical location and configuration of the excavation (arrowheads), measuring 1.2 × 1.9 cm. Note its intracortical location and well-circumscribed appearance. No associated periostitis is seen. (Prehistoric, adult male specimen, obtained from the Valley of Chicama, Peru, right femur.)

d. A photograph of the posterior surface of the distal femur demonstrates a similar cortical excavation (arrowhead), measuring approximately 1.4 cm in diameter. Observe the bony spicules at the base of the lesion. (Prehistoric, adult male specimen, obtained from the Valley of Chicama, Peru, left femur.)

Figure 3



Stress-related cortical irregularity and periostitis. This 24-year-old woman was engaged in many athletic activities, including gymnastics. She presented with a two-week history of knee pain. Conservative therapy was instituted, with clinical improvement during the next four to six weeks. Extensive cortical irregularity along the posteromedial aspect of the distal femur is seen. Observe excavation of the cortex and thick horizontal strands of new bone extending into the soft tissues.

RESULTS

Distal Femoral Cortical Excavation

Of the 21 museum specimens that demonstrated this lesion, 12 involved the left femur and nine involved the right femur. Sixteen of the specimens were obtained from adult cadavers, two from adolescent cadavers, and three from childhood cadavers (5–9 yrs. of age). In all cases, the site of the lesion was lateral to the medial supracondylar line and adductor tubercle, approximately 1 cm above the superior limit of the medial condyle (Fig. 1). The location corresponded to the osseous site of attachment of the medial head of the gastrocnemius muscle and was lateral to the site of the attachment of the tendon of the adductor magnus. The circular or oval lesions were variable in size, although several were larger than 2 cm in diameter. The osseous floor of the lesion was commonly irregular, with several protruding bony spicules. Mild elevation of the bone was noted at the periphery of the lesion in several cases. In no case was there evidence of a similar lesion anywhere else on the femur. The linea aspera was very prominent in two of the specimens, and associated mild proliferation of the medial supracondylar ridge was apparent in one specimen (Fig. 2). No definite relationship between the cortical excavation and the femoral length or configuration could be defined.

Distal Femoral Proliferative Cortical Irregularity

On radiographic examinations in ten patients, a short segment of cortical irregularity or spiculation was identified along the medial ridge of the linea aspera just above the adductor tubercle, especially in adolescents or children (8 patients). A poorly marginated zone of radiolucency within the bone, presumably representing osteoporosis, and small bony fragments in the adjacent soft tissues were also seen in a few cases. Although the size of the lesion was variable, most were elongated, measuring 3 to 5 cm in length. In one patient, a more florid pattern of periostitis was evident in which the zone of cortical irregularity and proliferation extended along the posteromedial aspect of the femur for a length of 10 to 12 cm in association with linear strands of new bone extending into the soft tissues at right angles to the parent bone (Fig. 3). This latter pattern resembled the hair-on-end periosteal proliferation noted in patients with Ewing sarcoma, although the bony outgrowths of the avulsive cortical irregularity were thicker and better defined.

Dissection of the single femoral specimen with a proliferative cortical lesion demonstrated palpable cortical irregularity that was not related to any tendinous fibers (Fig. 4). The aponeurosis of the extensor portion of the adductor magnus muscle was easily identified, but its fibers did not attach at the site of the lesion. On radiographic and gross pathologic examination, spiculated subperiosteal new bone formation and cortical thickening could be identified along the medial supracondylar ridge. Histologic evaluation confirmed the presence of a thickened periosteum with a shallow cortical defect composed of proliferating fibrous connective tissue (uniform spindle-shaped cells with eosinophilic fibrillar cytoplasm). At the base of the defect, irregular osseous edges demonstrated focal osteoclastic activity. The underlying trabecular bone was well formed and surrounded by mature fat.

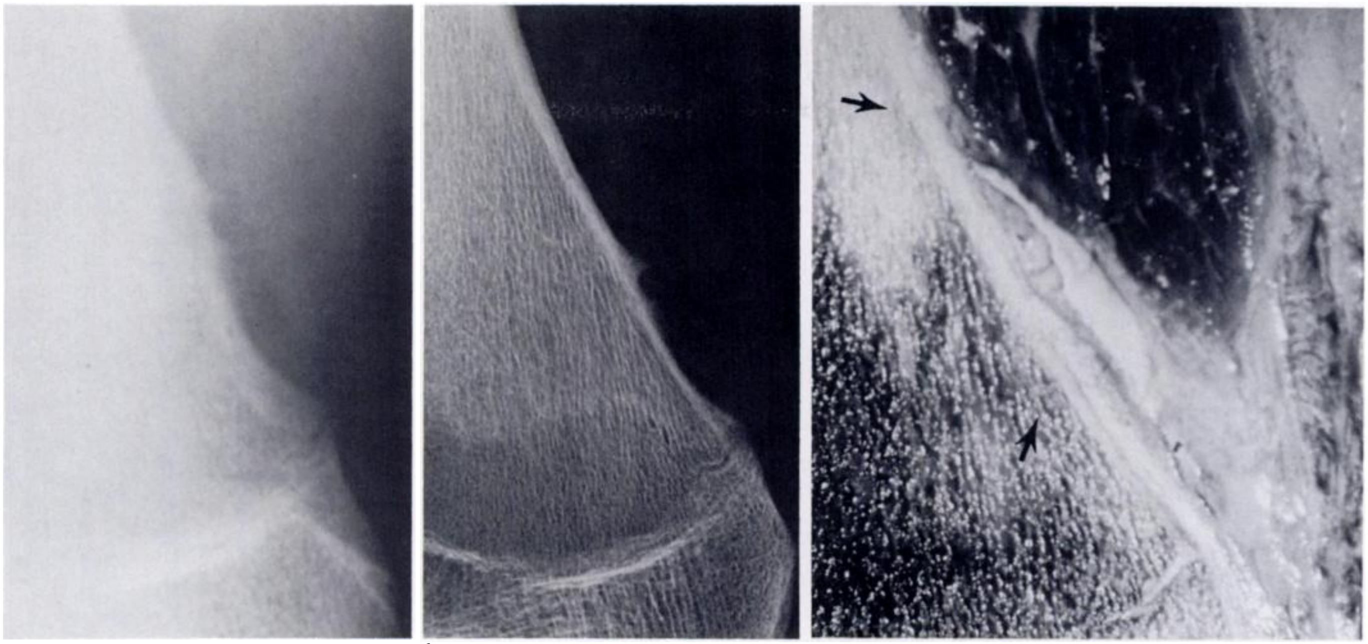
PATHOGENESIS OF THE LESIONS

The proximity of the extensor tendon of the adductor magnus muscle to the site of the typical femoral cortical proliferative lesion is consistent with a traumatic pathogenesis. Although histologic studies, including our own, fail to document aponeurotic, muscular, or tendinous fibers at the precise site of the lesion, the observed pathologic aberrations, although not specific, appear to represent a response to stress. Proliferation of fibrous and osteoid tissue and periosteum, osteoclastic activity, local hemorrhage, bony spicules, and a soft-tissue mass could result from a traumatic insult to the periosteum. Strengthening of the bone and firm adherence of the periosteum that occur with maturity could explain the relative infrequency of the changes in adults. The presence of this lesion in physically active adolescents and of an exaggerated abnormality in extremely athletic individuals (12) also supports a traumatic pathogenesis. There are no histologic data that indicate a neoplastic or infectious etiology.

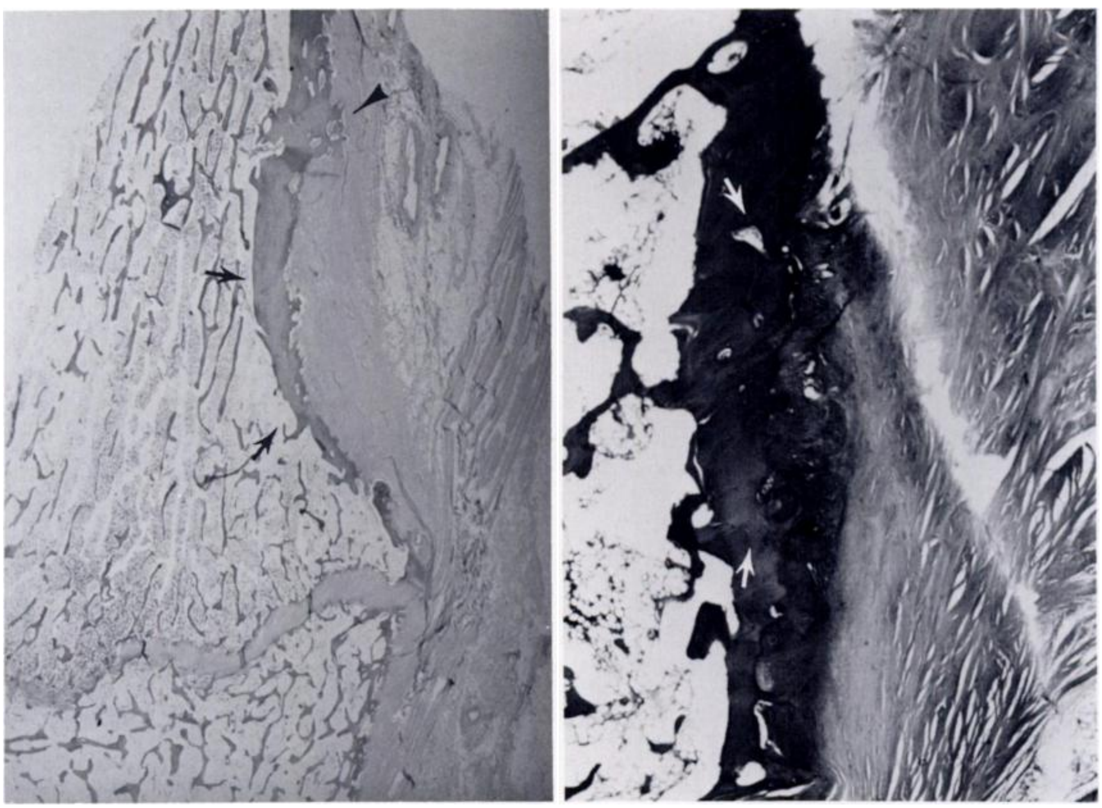
It is also possible that the proliferative cortical irregularity is the result of an exaggeration of the normal physiologic changes that occur in the growing metaphysis of a child or adolescent (20). Remodeling in this area, perhaps stimulated by the stress of intense physical activity, may be associated with accentuation of osteoclastic activity in the "cutback" zone that shapes the metaphysis. This may take place not in a uniform fashion about the circumference of the distal femur, but rather in areas in which the curvature of the metaphysis is most pronounced, *e.g.*, the posteromedial aspect. As the osteoclasts progressively erode portions of the cancellous trabeculae, appositional bone may be added in rapid fashion.

The pathogenesis of the distal femoral cortical excavation is more elusive. The possibility that this osseous alteration is an artifact produced by specimen decay is highly unlikely, owing to the lesion's constant position, the well-circumscribed nature of the defect, and the absence of similar changes

Figure 4



a. b. c.



d. e.

Distal femoral proliferative cortical irregularity. A 16-year-old black boy underwent a hip disarticulation for an undifferentiated soft-tissue sarcoma of the thigh. An incidental cortical lesion was evident in the distal posteromedial femur.

a and b. A preoperative radiograph (**a**) and specimen radiograph (**b**) delineate the characteristics of this lesion. Observe the minimal cortical thickening and small periosteal excrescences extending into the soft tissue. The spongiosa is entirely normal and a soft-tissue mass is not apparent.

c. A photograph of a coronal section demonstrates cortical thickening and irregularity (arrows). No tendinous fibers at the site of the lesion are identified.

d and e. Low- (**d**) and high-power (**e**) photomicrographs delineate a shallow cortical defect with an irregular cortical base (arrows) and persistent thickening with new bone formation (arrowhead). Fibrous connective tissue is seen within the defect, composed of uniform spindle-shaped cells with eosinophilic fibrillar cytoplasm. Osteoclastic activity is evident.

at other locations within the femoral specimens. The excavation could be produced by dissolution of the matrix of a benign cortical tumor or tumor-like lesion. In this regard, the site of the excavation is identical to the most common localization of a fibrocortical defect (15), and it may reasonably be asked if indeed the femoral excavation has been produced by such a defect. Several facts, however, suggest that this is not the case. Sixteen (76%) of the 21 femora that demonstrated this abnormality were derived from adult specimens. Cortical defects are more prevalent in children and adolescents, and reports would indicate that, although they may persist into adulthood, this sequence is unusual. Although most of the Hrdlicka paleopathology collection consists of adults, the remarkable incidence of this lesion in adult femora militates against their being fibrocortical defects. Furthermore, the absence of additional cortical excavations in these femoral specimens or in other bones in the Hrdlicka collection would be unexpected if the abnormalities were related to fibrous cortical defects, since such defects do occur at additional skeletal sites.

We believe that the distal femoral cortical excavation is a stress-related phenomenon. This belief is based upon several observations: (*a*) the site of the abnormality corresponds to the area of attachment of the medial head of the gastrocnemius muscle (Fig. 5); (*b*) the presence of small osseous irregularities at the base of a lesion could be the result of traction on muscle fibers; and (*c*) the cyst-like appearance evident on gross pathologic and radiologic examination could represent focal osteoporosis due to the hyperemia provoked by the traumatic insult. Radiolucent lesions have been described at osseous sites of insertions of other muscles (17).

Although we maintain that the distal femoral cortical excavation is traumatic in pathogenesis, we have no histologic data to support this view. In addition, we recognize that the absence of a similar finding at the bony attachment of the lateral head of the gastrocnemius muscle in all cases, and the absence of osseous proliferation along the adductor ridge in most cases are features that do not support a stress-related pathogenesis. We are unable to explain the discrepancy between the frequency of this lesion in prehistoric specimens and its apparent infrequency on clinical radiographs of adult patients. We could not verify any structural characteristics of the femoral specimens that would lead to exaggerated stress at the muscular attachments of the distal femur. Because the gastrocnemius provides the propelling force in walking, running, and leaping, it is plausible that these activities in the ancient civilizations of Peru were more pronounced than they are now. Hrdlicka (19) also believed that the lesion was related to trauma, although he could not explain why the abnormality was more frequent in the Chimu region on the coast than in the mountains. We have not been able to delineate any cultural characteristics of Peruvian populations that would account for these regional differences and, in particular, would explain the less common occurrence of a traumatically induced alteration in mountainous terrain. Regarding the apparent infrequency of the femoral cortical excavation in living adults, it is possible that subtle changes are being overlooked. It is also possible that with the increasing interest in and enthusiasm for physical activity and fitness that are evident today, the distal femoral cortical excavation may re-emerge.

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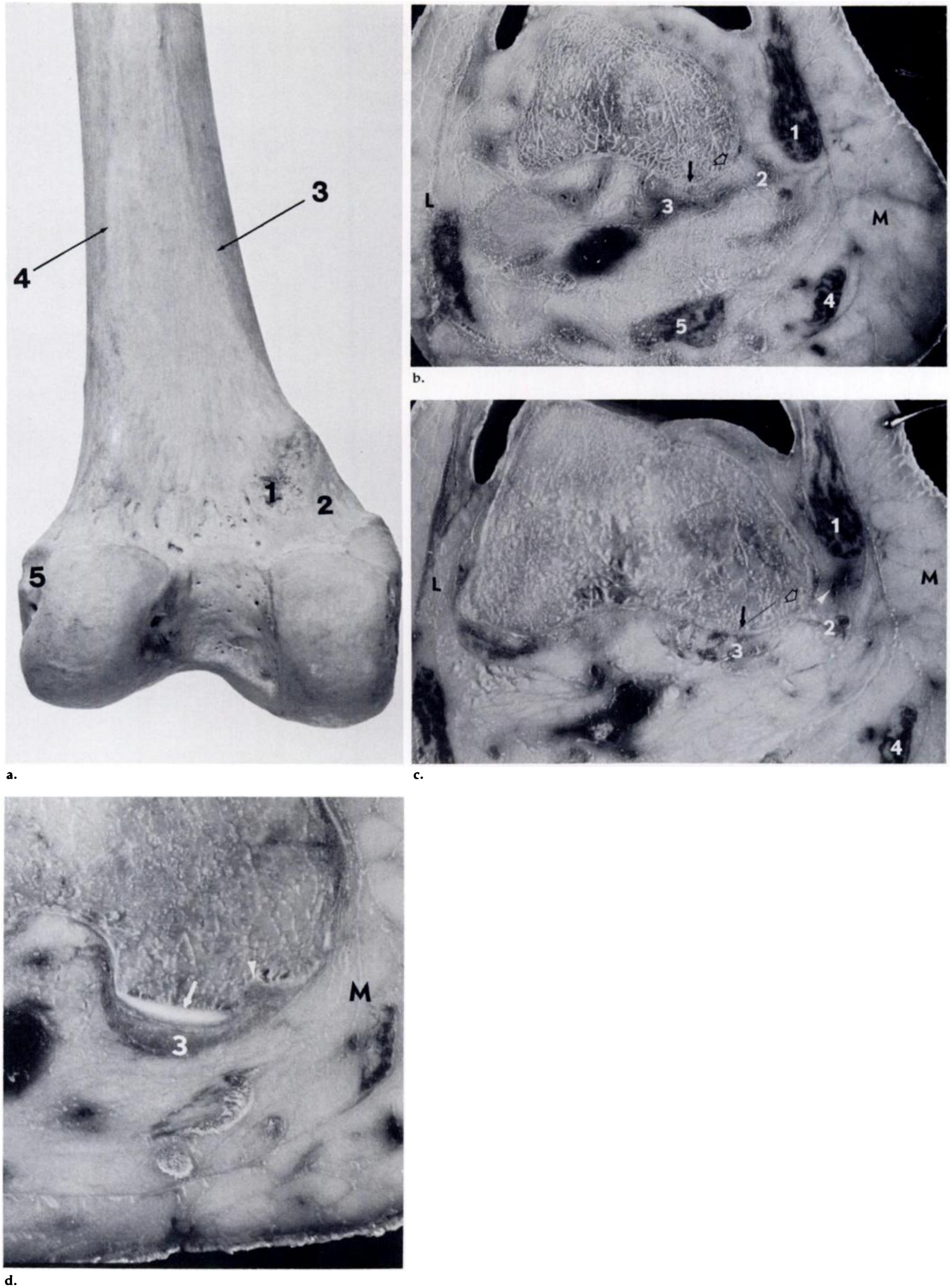
Anatomy of the distal medial femur with transverse sections of the leg slightly above the adductor tubercle. L = lateral; M = medial.

a. Osseous landmarks on the posterior surface of the bone are indicated. 1 = attachment site for the medial head of the gastrocnemius muscle; 2 = attachment site for the tendon of the adductor magnus; 3 = medial supracondylar line; 4 = lateral supracondylar line; 5 = attachment site for the lateral head of the gastrocnemius muscle.

b and c. The section shown in **b** is approximately 2.5 cm above the section shown in **c**. Air is present within the suprapatellar pouch. (M = medial; L = lateral; 1 = vastus medialis; 2 = approximate location of tendon of adductor magnus; 3 = medial head of gastrocnemius; 4 = sartorius; 5 = semimembranosus; closed arrow = site of osseous attachment of medial head of gastrocnemius; open arrow = site of osseous attachment of fibrous extension of adductor magnus tendon; arrowhead = superior genicular artery.) The adductor magnus muscle, arising from the inferior pubic ramus, ischial ramus, and inferolateral aspect of the ischial tuberosity, extends into the thigh and upper leg. The fibers from the ramus of the ischium attach by a broad aponeurosis to the linea aspera and the proximal part of the medial supracondylar line. Fibers from the ischial tuberosity descend almost vertically, ending in the lower third of the thigh as a tendon that can be palpated proximal to the adductor tubercle. A fibrous expansion connects the tendon to the medial supracondylar line. The aponeurotic attachment is interrupted by a series of openings formed by tendinous arches attached to the bony surface. Through the openings pass various vascular branches. The large medial head of the gastrocnemius arises from the posterior portion of the medial condyle, behind the adductor tubercle, and from the popliteal surface of the femur above the superior limit of the medial condyle. A portion of the medial head also arises from the capsule of the knee.

d. Transverse section just below the adductor tubercle, approximately 1.5 cm below **c**. M = medial; 3 = medial head of gastrocnemius; arrow = articular cartilage of femur; arrowhead = normal depression of femoral surface from which arise some fibers of the medial head of the gastrocnemius.

Figure 5



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