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Case Report

Two case reports showing a rather striking abnormal finding of unknown origin localized to the cortex of an amputated femur ☆,☆☆

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ABSTRACT

MRI scans of patients who have undergone leg amputation are rarely obtained; such scans may be performed when a mass is suspected to be related to the amputation or when inflammation (infection) is suspected, but the number of such cases is not large. In this study, however, we encountered 2 very striking cases in which short-tau inversion recovery coronal images taken for different purposes coincidentally showed a diffuse high signal intensity of the residual femoral cortex on the side wearing the artificial limb. Further examination of these images revealed that the superior margins of the artificial limb cup and the abnormal signal were almost identical and that the signal was only observed in the residual femur of the side using the artificial limb, suggesting that the change was caused by artificial limb usage. Despite the difficulty in imaging-pathologic correlation because the patients were still alive, we considered that the high signal was related to the characteristic microanatomy of the bone cortex and the mechanical changes caused by the effects of artificial limb usage on the residual femur. The 2 patients have not shown any specific events since then. Thus, while the residual femoral cortex may show findings of interest, these findings do not seem to require any specific treatment.

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Introduction

We encountered 2 cases in which imaging of the residual femur of a patient who began walking with an artificial limb after femoral amputation showed a notable high signal in the bone cortex on short-tau inversion recovery (STIR) images extending from the resection margin toward the proximal femur. To our knowledge, no previous report has described abnormal cortical signals in amputated limbs. Here, we present 2 cases and describe the suspected mechanisms causing these abnormal signals.

Case 1

A 44-year-old man had undergone amputation of both thighs after open fracture of his lower limbs in a car accident and was using artificial limbs. He underwent MRI examination because of swelling of his right thigh stump during gait training.

The STIR image obtained in the coronal plane showed a small amount of fluid collection and soft tissue swelling with slight elevation of signal intensity in the skeletal muscles of the femoral stump, indicating mechanical friction by the artificial limb (Fig. 1). However, no abnormalities were observed in the femoral bone cortex. Artificial leg gait training was initiated after the symptoms disappeared.

Follow-up MRI performed 1 year and 3 months later showed that the abnormal findings around the right stump had almost disappeared. However, diffuse and high signals were observed in the cortical bone on both sides and in the attached portion of the artificial leg (Fig. 2). No signal intensity change was observed in the cancellous bone, and the cortical and cancellous bone signals were separate. No apparent abnormal findings were observed in the cortical bone on plain radiography (Fig. 3). Since the patient complained of no symptoms on either side of the thigh, we did not perform any clinical intervention. He had no clinical complaints for 2 years and 9 months after the second MRI scan.

Case 2

The patient was a 27-year-old man who had undergone amputation of the left leg because of a traffic injury. Since the patient had malignant hyperthermia during the amputation surgery, the procedure was completed without sufficient fixation between the amputated femur and muscle fascia. MRI performed to screen for rhabdomyolysis showed no abnormal findings in the skeletal muscle and femoral bone. Subsequently, he was transferred to our hospital and started artificial leg gait training. As gait training progressed, dermatitis with subcutaneous exudates occurred due to friction between the stump and socket of the artificial limb. Therefore, MRI was performed again to check for the presence of muscles and osteomyelitis. The second MRI scan was performed 7 months after the patient had started gait training with the artificial limb.

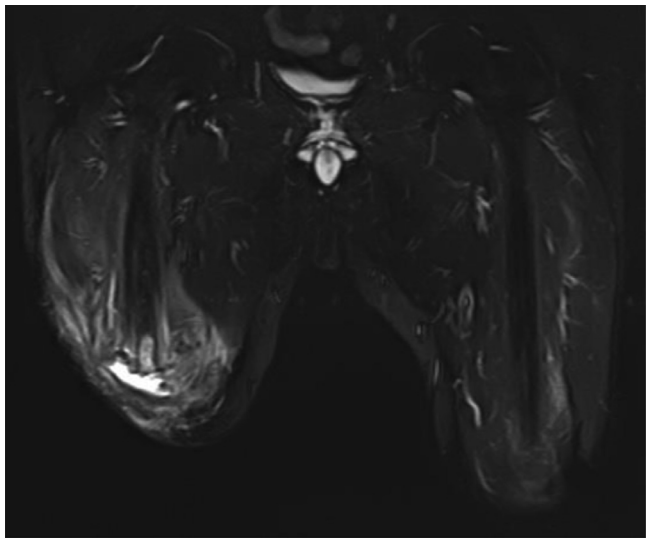

Fig. 1 – Coronal short-tau inversion recovery images of both thighs of a 44-year-old man. The stump on the right thigh was swollen. Diffuse hyperintensity was observed in soft tissues, including skeletal muscle and subcutaneous tissue. Small amounts of effusion and bone marrow edema were also observed adjacent to the stump. However, no areas of abnormal intensity were observed in the cortical bone.

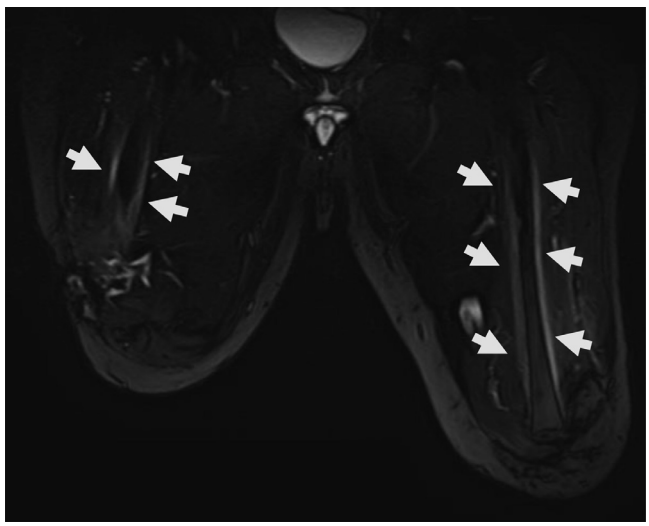

Fig. 2 – Coronal short-tau inversion recovery images of the thigh of the patient in Figure 1 obtained 1 year and 3 months later. Inflammation of the right femoral stump had almost disappeared. However, faint diffuse hyperintensity appeared in the cortical bone of both thighs (white arrows). Notably, while the cancellous bones showed no abnormal findings, a clear contrast was observed between the cortical bone and cancellous bone. The range of hyperintensity areas also corresponded to the attached range of the artificial limbs.

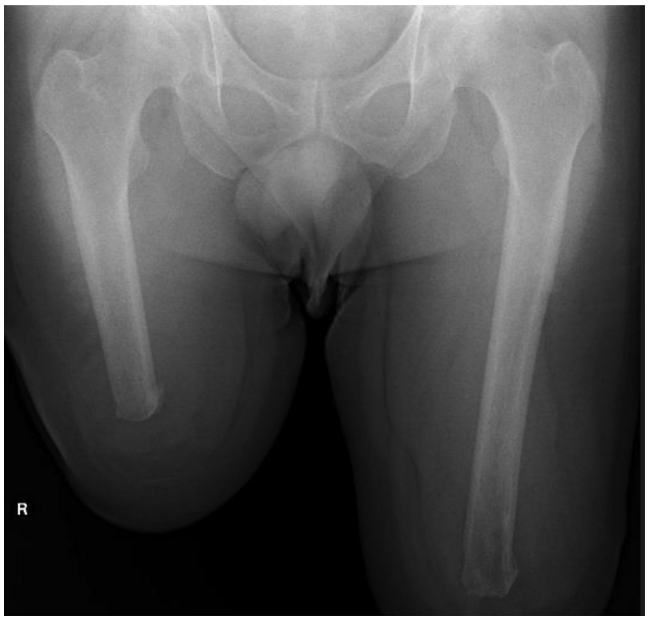

Fig. 3 – Plain radiographs of both thighs taken after the MRI examination in Figure 2. Although apparent hyperintensities in both thighs were observed on MRI, plain radiography showed no abnormal findings in cortical or cancellous bone.

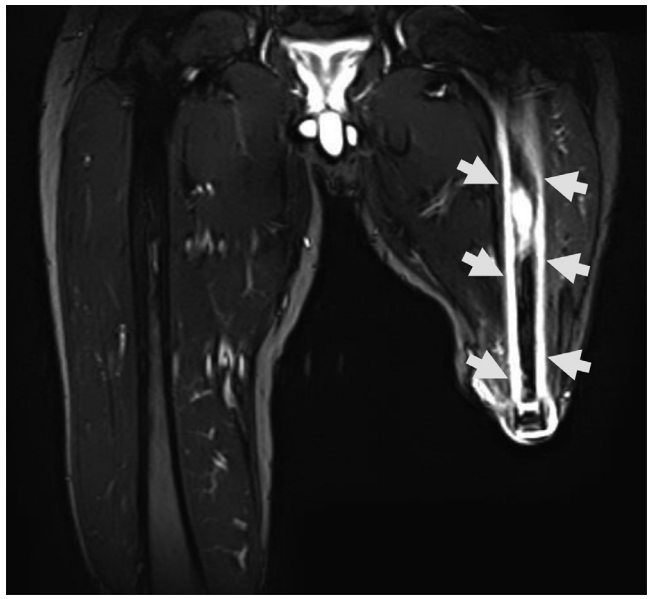

Fig. 4 – Coronal short-tau inversion recovery (STIR) images of both thighs of a 27-year-old man. The cortex on the prosthesis-wearing side had more strikingly prominent and diffuse hyperintense regions (white arrows). The extent of the hyperintense regions coincided with the extent of prosthesis wear. In other words, the upper edge of the socket and the upper edge of the high signal of the bone cortex appeared to approximately coincide. On the other hand, no abnormal intensity was observed in the right femur or the non-injured area. Patchy high signal intensity regions were also observed within the bone medulla in the left thigh. This image was taken 7 months after the patient began gait training with the prosthesis.

Similar to case 1, the coronal plane STIR image showed diffuse, marked hyperintensity in the cortical bone (Fig. 4), and it seemed to show a higher signal than that in case 1. However, similar findings were not seen on the contralateral side (Fig. 4), suggesting that the high signal in the cortical bone appeared after the artificial leg was attached. In case 2, patchy high-signal-intensity regions were also observed within the bone medulla (Fig. 4), but the plain radiograph showed no abnormal findings resembling case 1. On the basis of the MRI examination, the patient was diagnosed with osteomyelitis and underwent amputation and stump reformation procedures. He was able to walk using his artificial limb with no clinical symptoms.

Discussion

Reports describing the MRI findings for amputated femurs are extremely scarce. Most reports describe the imaging findings for neuromas arising in the incision scar [1–3]. Some reports have also described epidermoid carcinoma, which is commonly observed after chronic osteomyelitis [4]. Non-neoplastic lesions have also been associated with infections at the site of femoral amputation [5–7]. However, amputation has rarely been reported to cause bursitis [7,8]. In acute severe trauma, contrast examinations have been reported to provide information on blood flow in bone and soft tissues [9]. As described above, MRI evaluations have yielded various findings at the amputation site after femoral amputation. However, the present case report showed striking findings of diffuse STIR hyperintense signal confined to the cortex and limbus of the remaining femur after lower-limb amputation, which is quite different from the findings described previous reports.

We initially speculated that the artificial limb was crimped between the muscles and the periosteum, and that rubbing of the muscles and periosteum could have caused periostitis. However, since the lesions were confined to the cortex of the bone, periostitis was less likely. We also speculated that remodeling of the bone cortex might be involved, at least as a possible cause of the high signal intensity in this case. Fibroblasts that arise during remodeling generally show a high signal intensity on T2-weighted images. If they occur transiently and diffusely, they are likely to be involved in the high signal intensity in the cortex. Case 2, on the other hand, showed a markedly high signal that cannot be explained by fibroblast development alone, indicating that remodeling alone cannot explain these findings.

Therefore, we focused on the range of high signal areas in the bone cortex. In both cases, a cortical high-signal area was observed above the resection edge but did not extend to the proximal metaphysis or femoral neck. Furthermore, in case 2, the residual left femoral muscle group was markedly thickened and shortened, which may be attributable to the deformation of the skeletal muscles caused by the artificial limb,

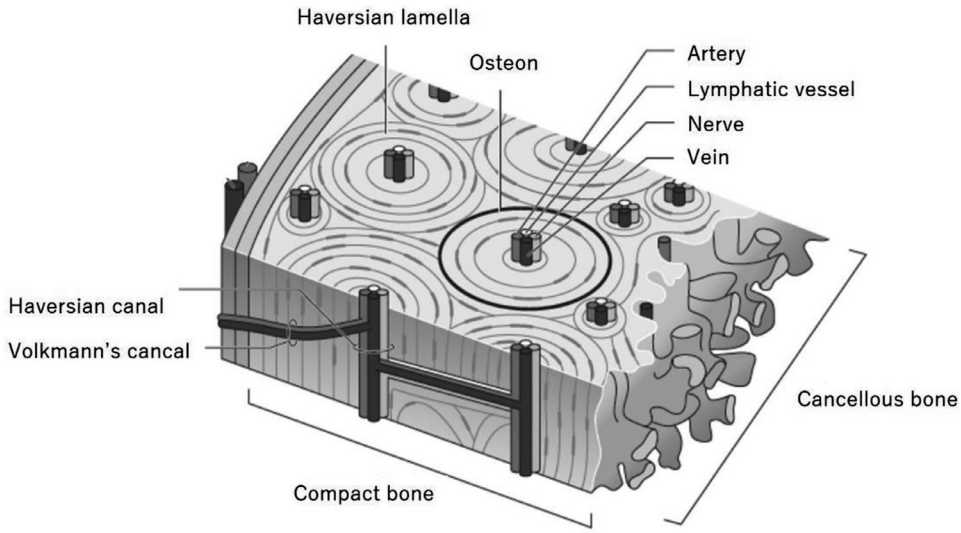

Fig. 5 – Microanatomy of the cortical bone. The structures of the cortical bone, such as the orthogonal Volkmann's canal and parallel Harversian canal, are arranged in an orderly manner. The arteries, veins, and lymph vessels are also associated with these canals in an orderly manner. The hyperintensity observed in the cortex may be caused by stasis of veins and/or lymph fluid due to squeezing by wearing an artificial limb.

that is, soft tissue deformation caused by chronic compression by the artificial limb. The upper edge of the artificial limb was almost coincident with the upper edge of the highly signalized bone cortex. In other words, the site of the upper edge of the socket when the artificial limb was fitted and the site of the upper edge of the high cortical signal were relatively the same. On the basis of these findings, we speculate that the leading cause of this striking high cortical signal on STIR images is likely related to chronic crimping of the residual thigh surface by the artificial limb.

An artificial limb constantly compresses all skeletal muscle groups on the thigh surface. In addition, these skeletal muscles are exposed to traction forces due to negative pressure in the direction of the artificial limb [10–13]. These external forces are assumed to affect the bone cortex, which resides deep within the bone.

Anatomically, however, cortical bone has an entirely different microanatomy from the trabecular bone. Cortical bone has well-ordered structures, such as orthogonal Volkmann canals and parallel Haversian canals (Fig. 5) [14–17]. In addition, arteries, veins, and lymphatic vessels run orderly and incidentally within these canals, even within the bony cortex [14–17]. Because the thigh is constantly subjected to the external forces described above under these conditions, we speculate that the draining of veins and lymphatic vessels toward the periosteum is prevented in the bony cortex, resulting in venous and lymphatic fluid stasis. This lymphatic and venous stasis may cause an increase in water molecules in the bone cortex, which in turn may be the primary cause of the marked signal elevation. Thus, we consider this striking finding of high signal areas along the cortex to reflect a "cortical congestion" condition. Case 2 also showed a high signal in the trabecular bone. Although the reason for this is not apparent, we speculate that venous and lymphatic stasis may have extended further into trabecular bone. However, such venous and lymphatic stasis is not entirely blocked by the artificial limb; therefore, this can be assumed to not cause any particular clinical symptoms.

Seven months after the artificial limb was placed, the signal intensity was remarkably high (case 2). However, the MRI signal at 1 year and 3 months (case 1) was visually lower than that in the 7-month image, showing only a faintly high signal. Therefore, the signal intensity increases for a while after the artificial limb is fitted but decreases after one year. This is because the artificial limb causes venous and lymphatic congestion, which increases the MRI signal intensity. Nevertheless, the signal decreases as the bone cortex gradually adapts to this condition, and the development of collateral pathways alleviates the congestion. However, because these are only visual evaluations and the number of cases was small, we would like to obtain pathological evidence and investigate the correlation between the duration of artificial limb wear and signal intensity in future studies.

In conclusion, the high intensity of the bone cortex on the wearing side observed in these cases may be due to remodeling as well as the significant external compression force from the residual thigh muscle group to the deeper bone cortex caused by the prosthetic foot, which resulted in venous and lymphatic stasis and a temporary increase in the signal. However, this signal elevation is probably transient and does not appear to be clinically problematic. Therefore, radiologists should be aware that similar findings, when observed, do not require specific treatment.

Patient consent

Written informed consent has been obtained from the patients whose cases are discussed in this article.

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