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# The Role of CT in Diagnosis and Follow-up of Osteosarcoma

M. Heller [1], H.-H. Jend [1], E. Bücheler [1], E. Hueck [2], and G. Viehweger [3]

[1] Radiologische Klinik (Direktor: Prof. E. Bücheler) des Universitätskrankenhauses Eppendorf, Martinistr. 52, D-2000 Hamburg 20, Federal Republic of Germany
[2] Zentral-Röntgeninstitut (Direktor: Prof. Dr. H.-J. Fernholz) des Klinikums, D-7500 Karlsruhe, Federal Republic of Germany
[3] Abteilung für Röntgendiagnostik in der Chirurgischen Universitätsklinik (Direktor: Prof. G. Viehweger), D-8700 Würzburg. Federal Republic of Germany

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Radiography is the most important tool in the diagnosis, staging, and follow-up of osteosarcoma. COSS offered the opportunity to assess the role of computer tomography (CT) in the diagnostic workup and monitoring of osteosarcoma and in the search for lung metastasis.

## Patients and Methods

Our experience is based on 72 CT examinations of the primary tumor and 62 CT examinations of the thorax of 36 patients, 16 males and 20 females (Tables 1a, b). Techniques of CT examination and modes of analysis of the CT data are listed in Tables 2 and 3. The modes of analysis were measurement of tumor extent, densitometry, highlighting, and perfusion study (time-density diagram). The CT *workup* of a tumorous limb is a laborious procedure. To minimize this disadvantage, a localizing digital radiogram is advisable (Fig. 1). The scans should start at the juxtatumoral joint. The scans of 2 mm slice thickness should be placed at intervals only to give some representative images of the malignancy. *Analysis* of tumor morphology will be improved by special software programms that are adjusted for optimal bone-density visualization ("bone window", "high resolution mode" (Fig. 2a, b). With modern fast equipment one can perform rapid sequential scans to study contrast-medium perfusion patterns within the tumor.

The first step in analyzing the CT data is the visual appraisal of the CT image. Next, tumor extent is measured densitometrically and using electronic markers. Electronic highlighting of areas of pathologic attenuation coefficients facilitates quantitation of the tumor extent. Finally, the perfusion pattern of the tumor can be studied by means of a sequential CT. Density changes after application of contrast medium should be correlated to nontumorous structures in the same scan. Thus, changes of tumorperfusion in the course of chemotherapy can be assessed.

*Offprint requests to:* Dr. Martin Heller (address see above)

**Table 1a.** CT examination (20 female, 16 male patients)

| | |
|---|---|
| CT of primary tumor | 72 in 36 patients[a] |
| CT of thorax | 62 in 28 patients |
| CT of abdomen | 3 in 3 patients |
| Pulmonary metastasis | 13/28 |
| Osseous metastasis | 2/36 |
| Liver metastasis | 2/36 |

[a] Hamburg: 33 patients; Karlsruhe: two patients; Würzburg: one patient

**Table 1b.** Tumor localization

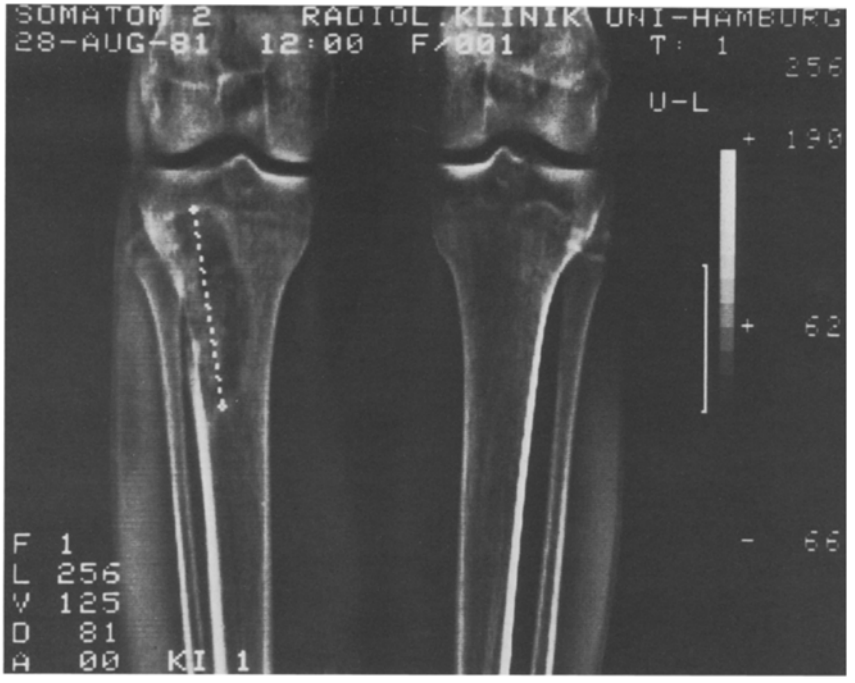
| Site | | No. of patients |
|---|---|---|
| Upper extremity | Humerus | 4 |
| | Radius | 1 |
| Lower extremity | Femur | 19 |
| | Tibia | 10 |
| Pelvis | | 2 |

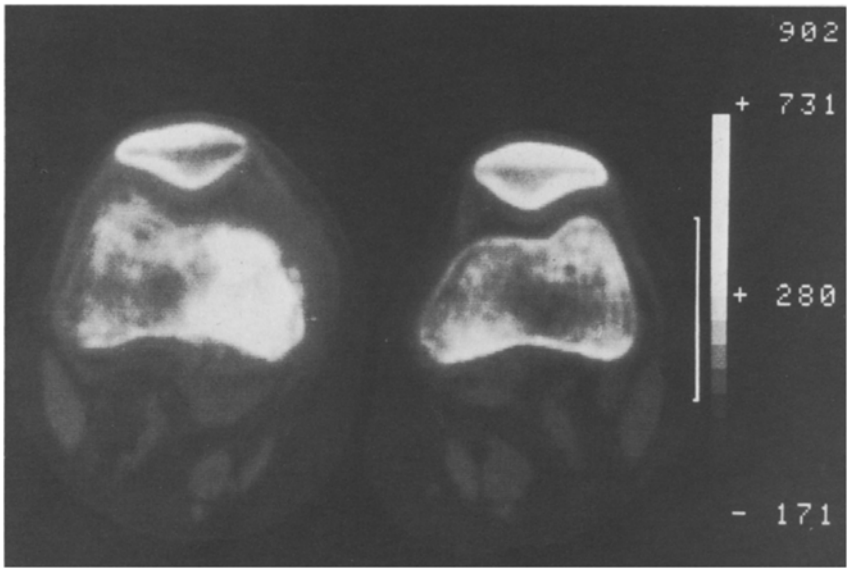
**Table 2.** Techniques of CT examination

| Methods of examination |
|---|
| Digital radiogram (CT) |
| 720 Projections in 360° |
| Slice thickness 2 mm |
| High resolution |
| Magnification view |
| Densitometry |
| Dynamic CT |

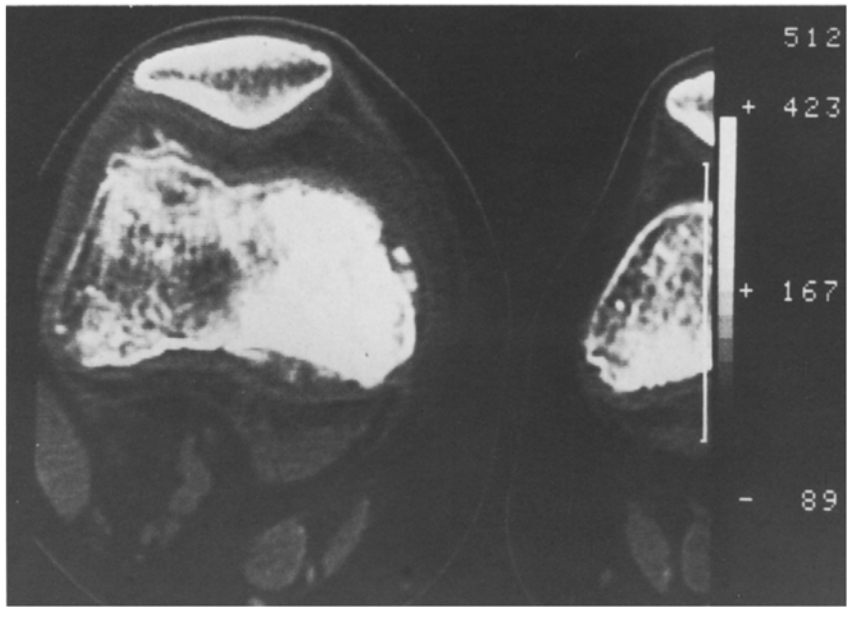
**Table 3.** Modes of CT analyses

| |
|---|
| Measurement of tumor extension |
| Densitometry |
| High lightening |
| Perfusion study (time-density-diagram) |




a




b

**Fig. 1.** Digital a–p radiogramm: Osteosarcome of right proximal tibia, size 67 mm

**Fig. 2. a** Osteosarcoma of right distal femur. Scan: 8 mm slice thickness. **b** Same patient as in **a**. Scan: 2 mm slice thickness, high-resolution mode. Better visualization of bony structures and tumor signs such as sclerosis, periostal elevation, and low-density soft-tissue changes in comparison with surrounding muscles

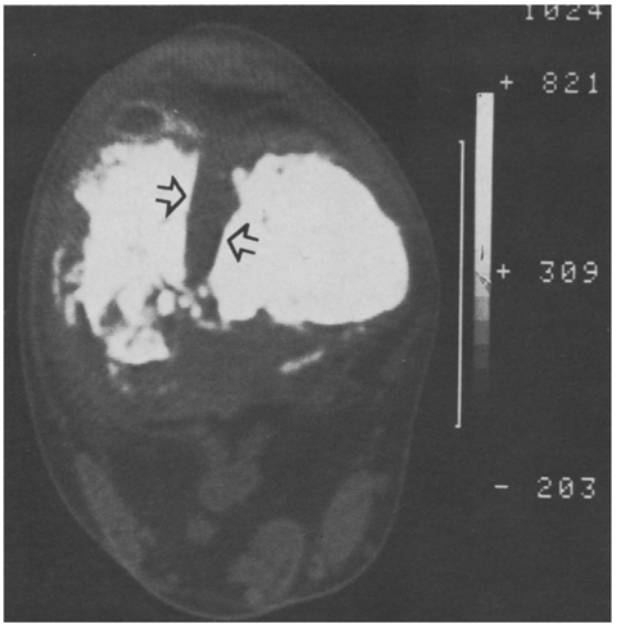



**Fig. 3.** Sclerotic osteosarcoma of right distal femur. Wegder-shaped defect after biopsy (⇓ ⇑ )

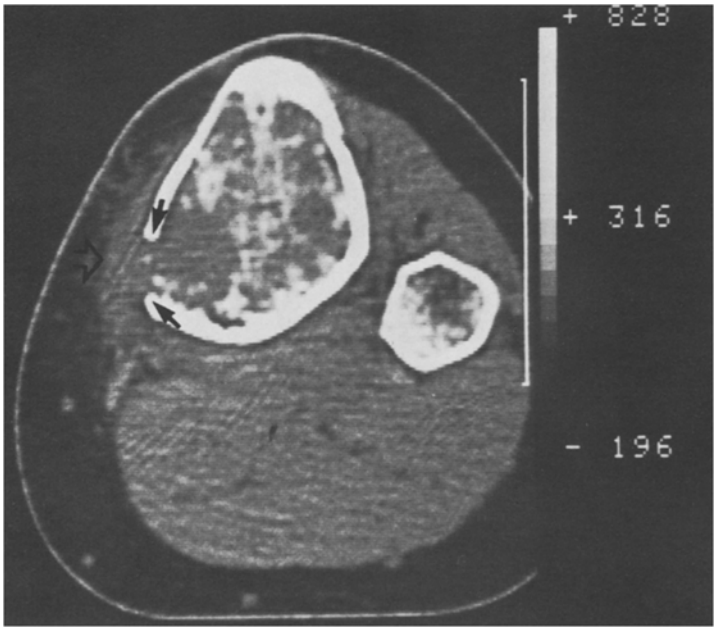



**Fig. 4.** Lytic osteosarcoma of left proximal tibia. Sharply delineated cortical defect after biopsy (⇓⇓). Destruction of cancellous bone. Small soft-tissue mass ( ⇓ )

## CT in Diagnosing Osteosarcoma

At the first glance, CT seems to have no advantages over conventional X-ray investigation as it is time-consuming. Reliable conventional X-ray investigations are easy to perform, produce excellent results, and thus must be considered the "gold standard". On the other hand, CT offers the great advantage of an unblurred axial view of both soft tissue *and* bony structures. Even the primary picture offers very complex information that may be analyzed on the basis of shape, contour, and pattern. The appraisal of parosteal, periostal, cortical, cancellous, and medullary structures by means of these criteria will enable the experienced investigator to classify the tumor (Figs. 3, 4). Special care must be taken in assessing the intramedullary extent of the tumor and in searching for skip metastasis proximal to the tumor site. Elevated medullary densities that can be monitored only densitometrically and not visually must be considered tumor infiltration. Other structural changes should be interpreted as on conventional X-ray films: bony destruction signifies osteolysis, sclerosis new bone formation (Fig. 5), and periosteal elevation (Codman triangle; Fig. 6) and spicula (Fig. 7) indicate tumorous changes.

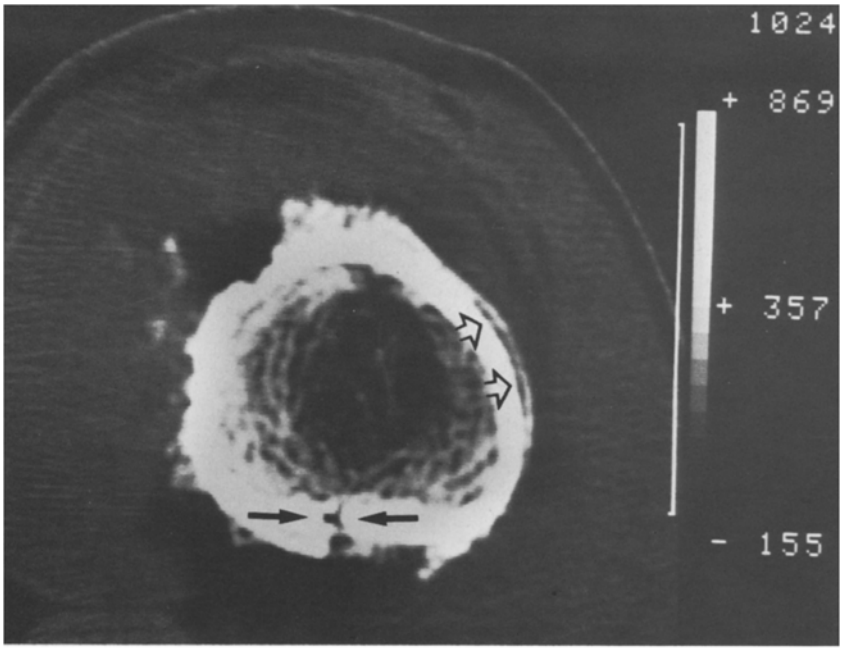



**Fig. 5.** Large soft-tissue mass with ossifications. Coarsened bone structures. Irregular thickening of cortical ring, which is broken (⇓). Periostal elevation (⇓)

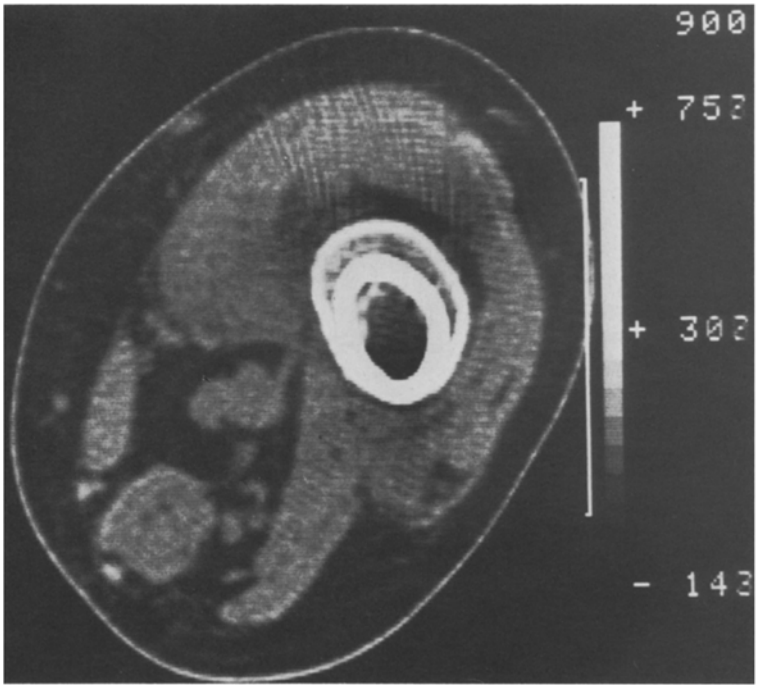



**Fig. 6.** Almost circumferential elevation of thickened periost (i. e., Codman triangle)

Nearly all patients showed some soft-tissue changes near the tumor site (Figs. 2, 3, 4, 5, 6, 7, 8). These may be considered as part of the tumor only if they show new bone formation. A hypodense periosteal band which can often be seen, may represent an edema or tumor infiltration (Fig. 2b).

### CT in Follow-up Osteosarcoma

In the CT follow-up, this hypodense periosteal band shows the closest correlation to an effective medical treatment, with the exception of simultaneous growth of the bony parts of the tumor. Perfusion studies should monitor the effects of the treatment. Very often the uncomfortable heat sensation experienced when contrast medium is applied induces involuntary movement in the patient. This causes sequential measurements of different body slices rendering the investigation useless. The use of nonionic contrast agents will reduce such problems. Sequential CT visualizes changes of tumor perfusion but gives no information on bone

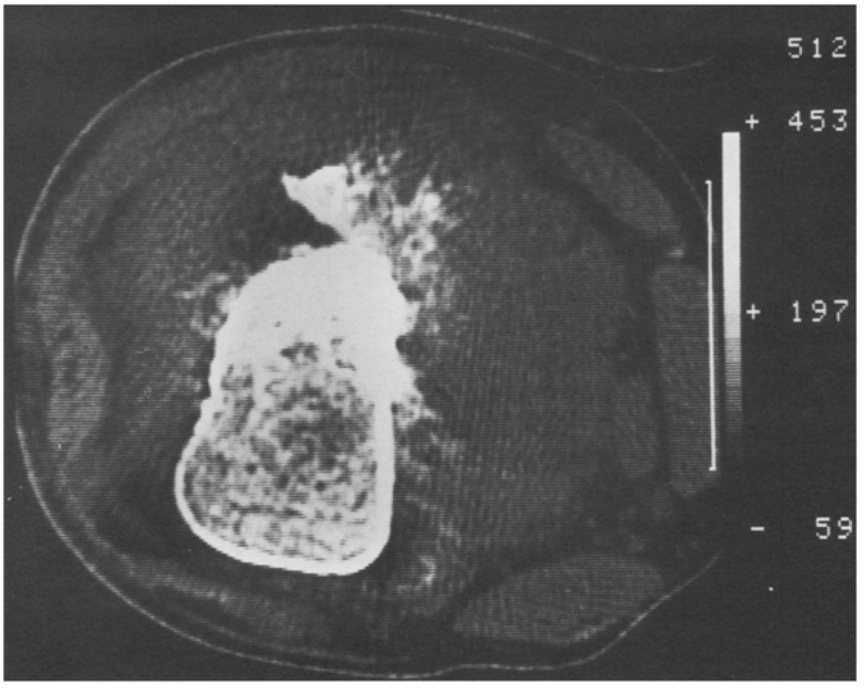



**Fig. 7.** Spicula "bursting" in soft-tissue mass

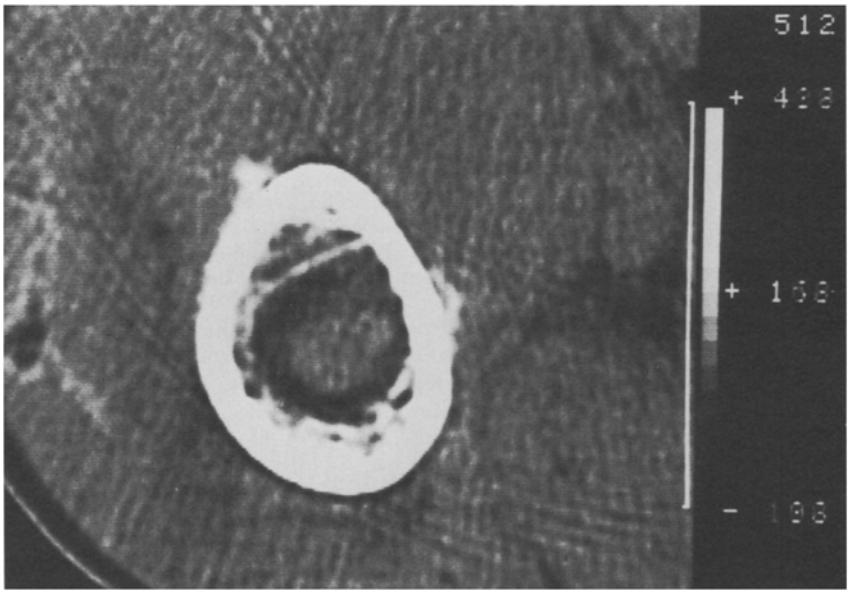



**Fig. 8.** Medullary tumor growth

metabolism. Vascular changes resulting from chemotherapy may lead to changes in the perfusion patterns of the contrast agent. This problem can also be studied scintigraphically.

## Conclusion

In general, CT is superior to conventional laminography in detecting pleural and pulmonary nodes. In the case of the juvenile lung or of calcified nodes, laminography or even ordinary X-ray films provide equal information. Nonetheless, subtle pleural metastasis at the thoracic wall (Fig. 9) or at the mediastinum can be visualized better by CT.

The role of CT in the diagnostic workup of an osteosarcoma patient may be described as follows: (1) Conventional examination using X-ray and laminography of the lungs are the primary diagnostic tools. (2) Isotope studies should be performed for

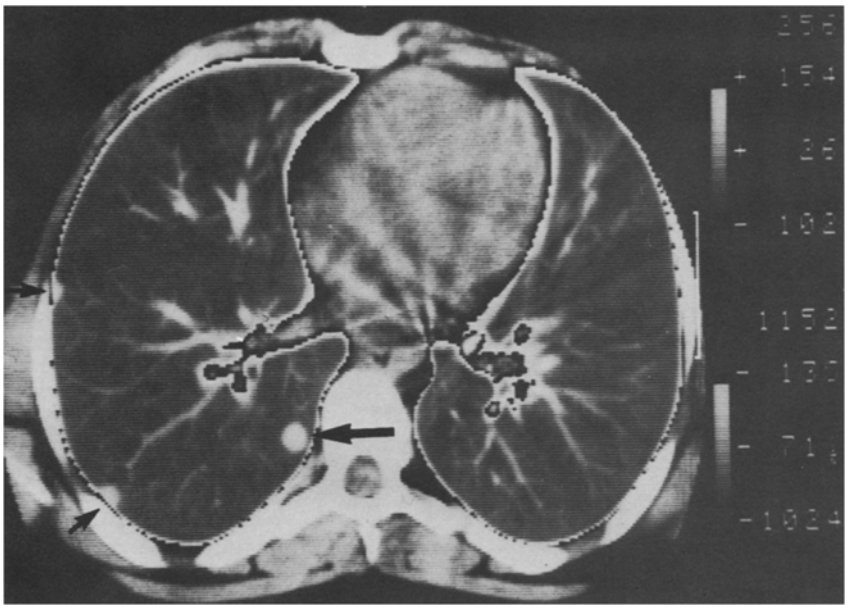


**Fig. 9.** Paravertebral pulmonary metastasis (→) and lateral subpleural metastasis (⬇⬇)

screening of all areas of high bone metabolism, especially to detect skip metastasis. A dynamic scintigram is advisable. (3) Finally, CT should define the true extent of the tumor, especially the intramedullary extent, verify the results of the other methods, and show the site best suited for bone biopsy. A sequential CT study is recommended. The lungs should be scanned only if laminography is negative or leaves some doubt about metastatic spread. This diagnostic scheme is also valid for monitoring the course of the disease.

At present, we have no pertinent CT criteria from which we can claim success of the osteosarcoma chemotherapy. On the other hand, CT gives us excellent information about whether the treated osteosarcoma is progressing.

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