

# Chapter 10

## Conservation of the Epiphysis While Removing Metaphyseal Bone Tumors: Epiphysiolytic Before Excision

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**Abstract** Physal distraction – when used for epiphysiolytic rather than for lengthening – provides a safe margin of resection in appropriate patients. The technique does not delay tumor treatment. Placement of the external fixator requires only 15 min and should be done a fortnight before the date established for surgery. We include in this chapter a video tutorial of the placement technique.

### 10.1 Introduction

Physal distraction has been extensively used for bone lengthening [4–6] and for correcting angular deformities [1, 2, 8]. We now describe its use in facilitating the excision of malignant bone tumors of the metaphysis. Such use can enable preservation of the epiphysis.

The absence of anastomoses between epiphyseal and metaphyseal vessels means that in those cases where imaging methods determine that the epiphysis has not been affected by the tumor, it is possible to conserve the epiphysis and the joint

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while resecting the tumor. This is made possible by physeal distraction according to Cañadell's technique.

## 10.2 Patients and Methods

Between March 1980 and December 2014, we operated on more than 1000 patients with pediatric bone sarcomas. Intercalary reconstructions were carried out in 168 patients, and many of these reconstructions were made possible by means of physeal distraction. Of these 168 patients, the mean age was 9.4 years; there were similar numbers of males and females. The histological diagnosis was osteosarcoma in two-thirds of the patients (n: 109) and Ewing's sarcoma in the remaining one-third (n: 59).

## 10.3 Indications Conservation of the Epiphysis While Removing

The indications for Cañadell's technique were:

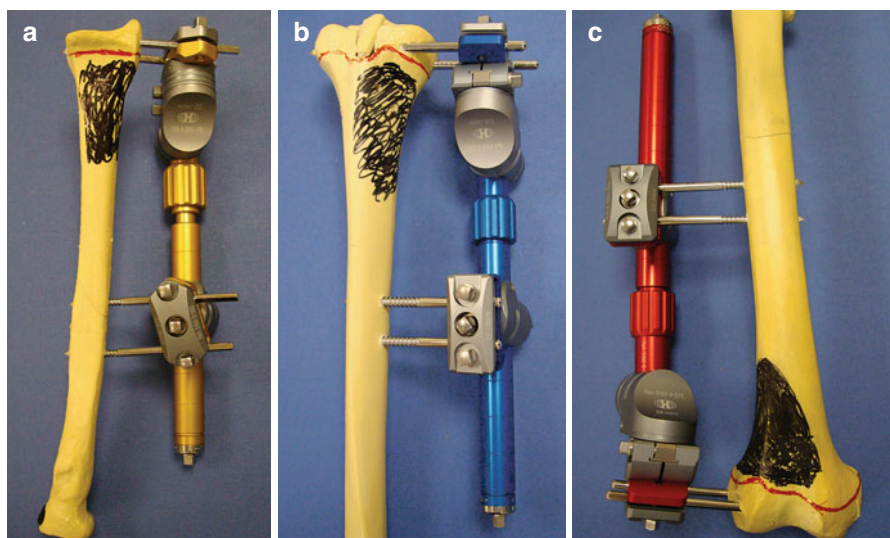
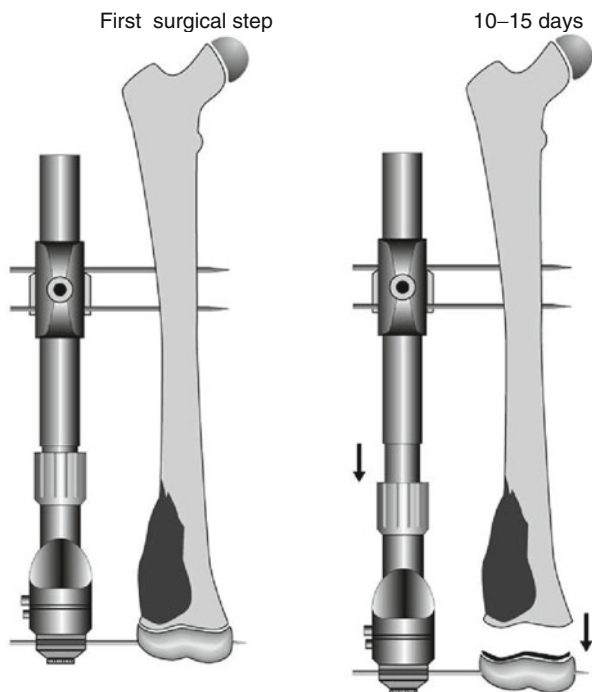
1. *Location of the tumor in the metaphyseal region.*
2. *The physeal cartilage had to be open.* A patient's age is an important consideration here. In about half of our pediatric patients, the tumor had not involved the physis; the mean age of this group was 11 years. In patients who have nearly finished growing, the probability of tumoral cells having crossed the physis is higher, and it is more difficult to achieve physeal distraction. Other authors [7] have reported a similar incidence of micro- or gross- extension to the epiphysis from metaphyseal bone tumors.
3. *The tumor must not have transgressed the physis.* Radiography, arteriography, CT, and particularly MRI were used to demonstrate this pre-operatively, and histological examination was then used to corroborate the findings of such imaging studies [3].

## 10.4 Operative Technique (Video 10.1)

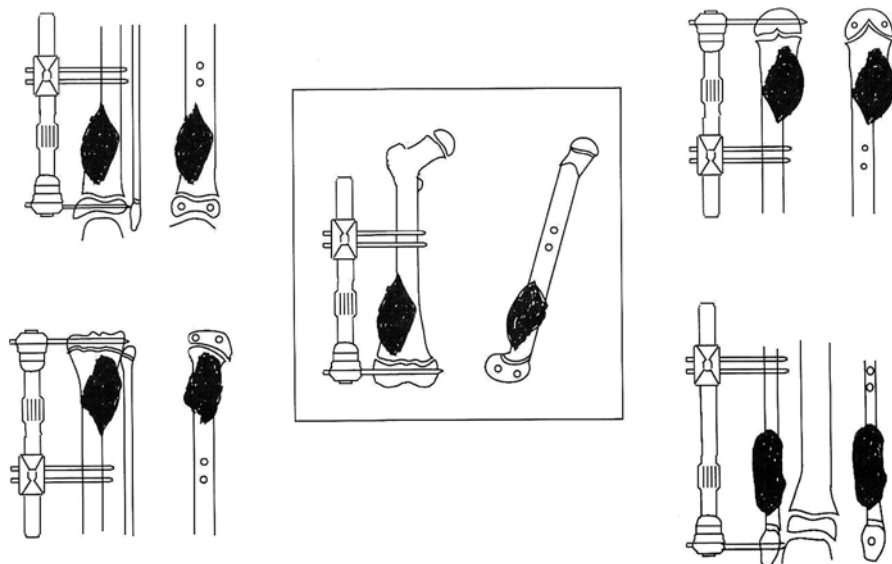
The surgical technique usually consists of two phases:

**Phase one** (Fig. 10.1). Two pins are inserted into the epiphysis and another two into the diaphysis at a distance from the tumor (8–10 cm away if possible). An external monolateral fixator with a T-shaped piece (Fig. 10.2) for the epiphyseal pins is attached (Fig. 10.3). We usually use Schanz pins of 5 or 6 mm diameter. In very young children, 4 mm pins could be strong enough for epiphysiolysis.

**Fig. 10.1** Diagram showing the first surgical step



**Fig. 10.2** (a–c) Devices used in young children for distal tibia, distal fibula, and distal radius (yellow) and in adolescents for proximal tibia and humerus (blue) and distal femur (red). All devices have a T-shaped piece in order to put the two epiphyseal pins perpendicular to the diaphysis

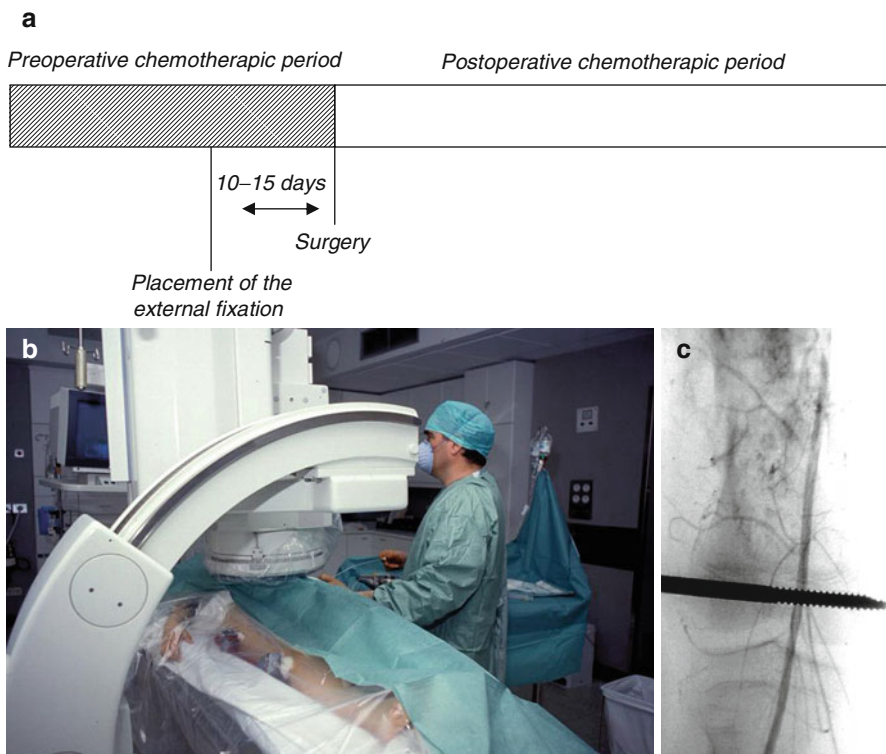


**Fig. 10.3** Diagrams showing the placement of the pins in distal femur, proximal and distal tibia, proximal humerus, and distal fibula

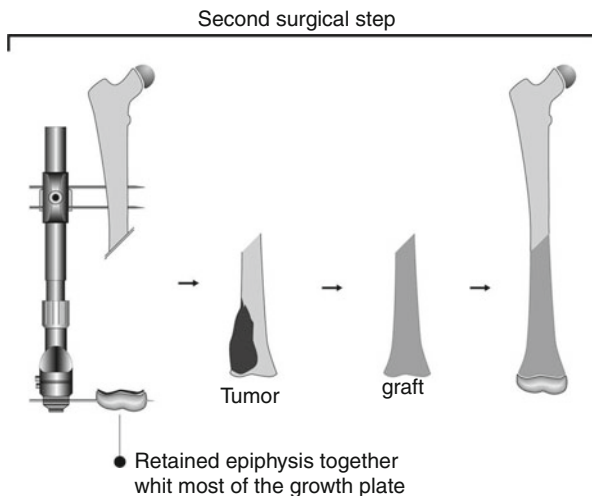
Distraction is begun in the operating room and continues at the rate of 1–1.5 mm/day until 1 or 2 cm of distraction is achieved. During the first few days nothing happens, but after between 7 and 14 days of distraction the patient usually reports pain, and this indicates rupture of the growth plate: radiography will show disruption of the physis. In our series, the mean time over which distraction was applied was 10 days. This first phase can be carried out while the patient is finishing the course of neoadjuvant chemotherapy; despite the external fixator being in place, even intra-arterial procedures can be used without problems [9] (Fig. 10.4). We usually operate on a patient the day after the final intraarterial neoadjuvant procedure.

**Phase two.** En-bloc resection of the tumor is performed by diaphyseal osteotomy, leaving a wide margin. The metaphyseal end of the resection is already effected by the distraction. If the prior imaging methods clearly indicated an absence of tumor in the epiphysis, the operation is completed, in this second surgical step, by reconstruction with an intercalary graft (Fig. 10.5).

In the past, before the advent of MRI, with cases for which we could not be sure that the tumor had not involved the epiphysis, the resected tumor was sent immediately for histological examination, and chains of PMMA containing gentamicin were inserted into the space held open by the fixator. If the pathologist reported absence of tumor at the edges of the resected segment, the chains of beads were withdrawn and a bone graft was inserted (Fig. 10.4). If, on the other hand, the pathologist were to find tumor cells, the procedure would be to resect the epiphysis and reconstruct the limb by other means: prosthesis, osteoarticular allograft, or arthrodesis. In our series the latter scenario was only necessary in



**Fig. 10.4** (a) It not necessary to delay the protocol of treatment. The first surgical step is carried out during the pre-operative chemotherapy period. (b, c) In osteosarcoma patients, we use intra-arterial cisplatin as a part of the neo-adjuvant chemotherapy protocol. The angiogram also clearly shows that vascularization of the epiphysis is not connected with that of the metaphyseal tumor. We usually carry out resection of the tumor the day after the last intra-arterial neoadjuvant procedure

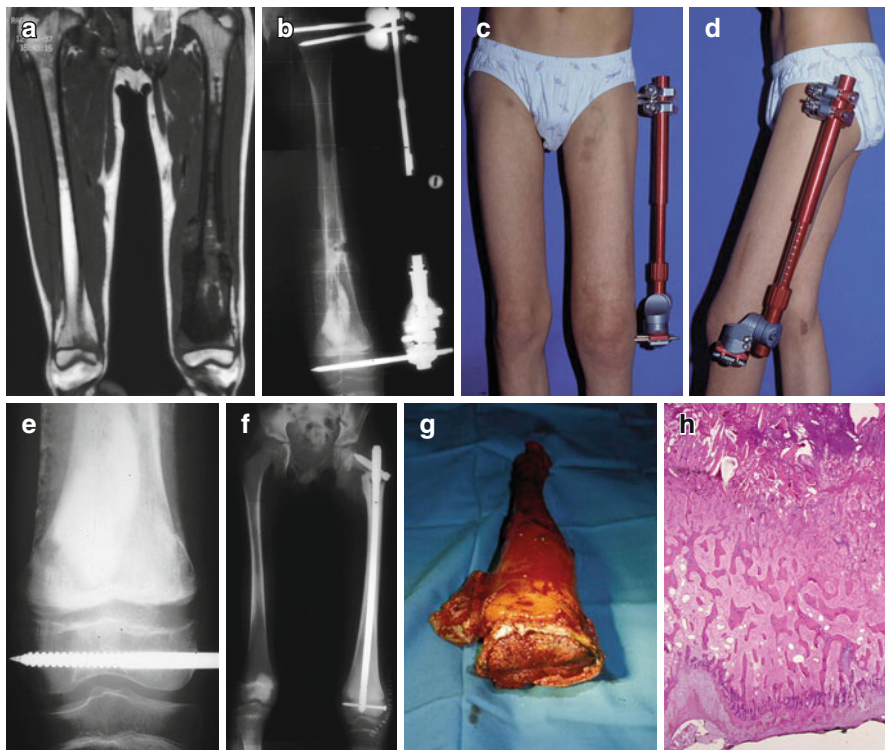


**Fig. 10.5** Diagram showing resection and reconstruction



**Fig. 10.6** After distraction (a), surgery is easier. The perichondrium is cut (b–d). Only diaphyseal osteotomy is required (c), because the metaphyseal “osteotomy” is already done. The resected piece is covered by a thin layer of growth plate which constitutes a safe margin (e), while most of the growth plate remains attached to the epiphysis in the patient (f)

one patient, whose prosthetic reconstruction proceeded without problem, and who suffered no local recurrence. MRI has removed the uncertainty over epiphysis involvement, and so the three-step technique described in this paragraph is no longer generally required (Figs. 10.6 and 10.7).



**Fig. 10.7** Osteosarcoma involving two-thirds of the femur in a 13-year-old boy. MRI (a) shows some edema between the tumor and the growth plate. In this particular case, the proximal pins were placed in the femoral neck due to the tumoral extension (b–d). Physal distraction was achieved (e). Reconstruction was carried out with an intercalary allograft in the second surgical step (f). The allograft used was 2 cm longer than the resected piece (g, h). The resected piece (g) together with the biopsy scar. Staining of the distal margin with Indian ink (h) shows that the margin is free of tumor, because there is a thin layer of growth plate cells covering the resected bone

In cases of large femoral tumors, sometimes the proximal pins have to be inserted in the femoral neck (Figs. 10.7 and 10.8).

The choice of the kind of osteosynthesis device in the graft and in the remaining physis and epiphysis can play an important role in the final leg-length discrepancy (see Chap. 12). In this respect, for children near the end of growth, it may be appropriate to insert an allograft longer than the resected piece.

## 10.5 Discussion

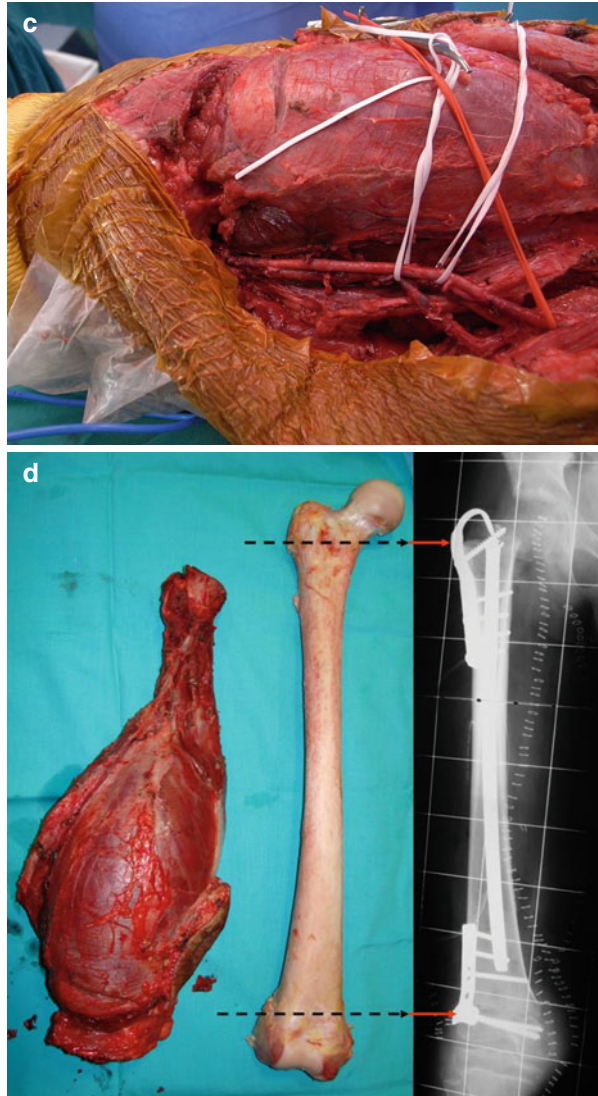
When resecting a tumor, the surgeon must be certain that no malignant tissue is left behind. Many authors agree that a 2–3 cm margin is safe in bone sarcomas. This means that, when the tumor is in the metaphysis close to the growth plate, resection with such a margin implies loss of the adjacent joint.



**Fig. 10.8** (a) A huge osteosarcoma in the right femur of a 12 year-old boy. A large transquadri-cipital open biopsy was performed elsewhere, and amputation was advised. MRI shows extension of the tumor near the distal epiphysis. (b) After neoadjuvant chemotherapy an external fixator was placed. Note the location of the proximal pins. Epiphysiolysis was achieved. (c) An intra-operative picture showing dissection of the vessels. (d) Postoperative x-ray. (e) The patient's leg function 7 years later was acceptable



**Fig. 10.8** (continued)





**Fig. 10.8** (continued)

However, by definition, the wide margin is assumed to refer to a layer of normal tissue, as opposed to reactive or inflammatory tissue surrounding the tumor.

In tumors that do not cross the growth plate, our technique based on previous physal distraction, provides a safe margin while averting loss of the epiphysis. When present, the growth cartilage itself provides a dependable margin of safety: the 2–3 cm margin suggested by most authors is unnecessary in this specific context. This view is supported by the fact that in our series as well as in other series (see Chap. 14) no tumor has been observed to recur locally in epiphysis that has been conserved in accordance with the procedure we describe.

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