Chapter 13
Other Techniques for Epiphyseal Preservation

Mikel San-Julian

Abstract Most pediatric bone sarcomas are located at the metaphysis of long bones. In selected cases, the epiphysis can be preserved by metaphyseal or intra-epiphyseal osteotomy. Compared to intra-epiphyseal osteotomies, physeal distraction before excision of the tumor has some advantages, but in some cases osteotomy is indicated.

Keywords Limb salvage • Metaphyseal osteotomy • Intraepiphyseal osteotomy • Joint preservation

13.1 Metaphyseal Osteotomy

With diaphyseal tumors, preservation of the epiphysis is not a problem. With metaphyseal tumors, however, preservation of the epiphysis is not always possible although there are still some metaphyseal locations from which a tumor can be safely excised by metaphyseal osteotomy, thus avoiding damage or resection of the growth plate.

In young children, the biological impetus towards growth and bone formation is so strong that even chemotherapy does not stop it; a tumor that is originally near or in contact with the growth plate can be displaced by new bone formation to the diaphysis during the neoadjuvant chemotherapy period, and thus intra-epiphyseal osteotomy can preserve not only the joint, but also the entire growth plate (Figs. 13.1 and 13.2).

13.2 Intra-epiphyseal Osteotomy

Prior to the first publications of our work, the possibility of preservation of the epiphysis in metaphyseal bone tumors was apparently largely overlooked, and alternative techniques, such as intra-epiphyseal osteotomy [9], have only been

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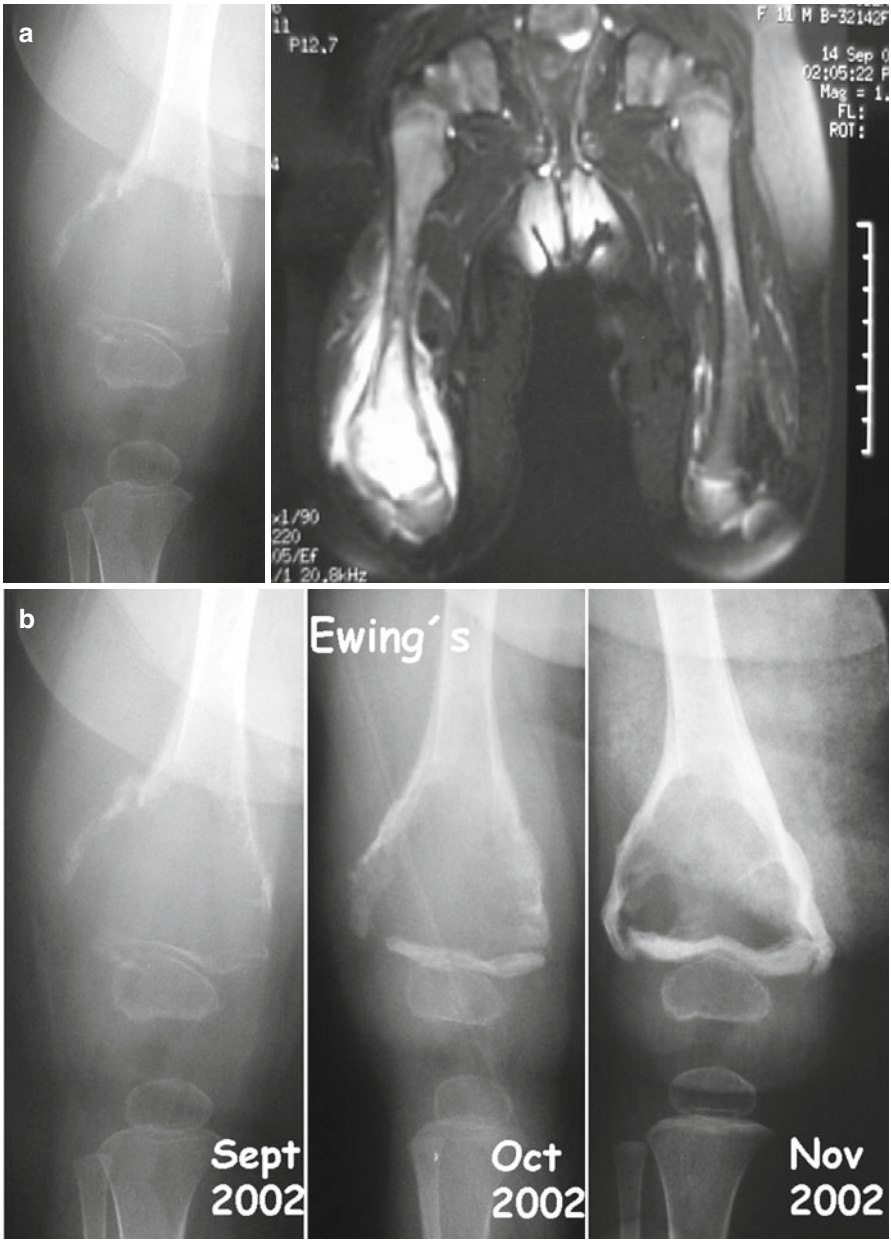
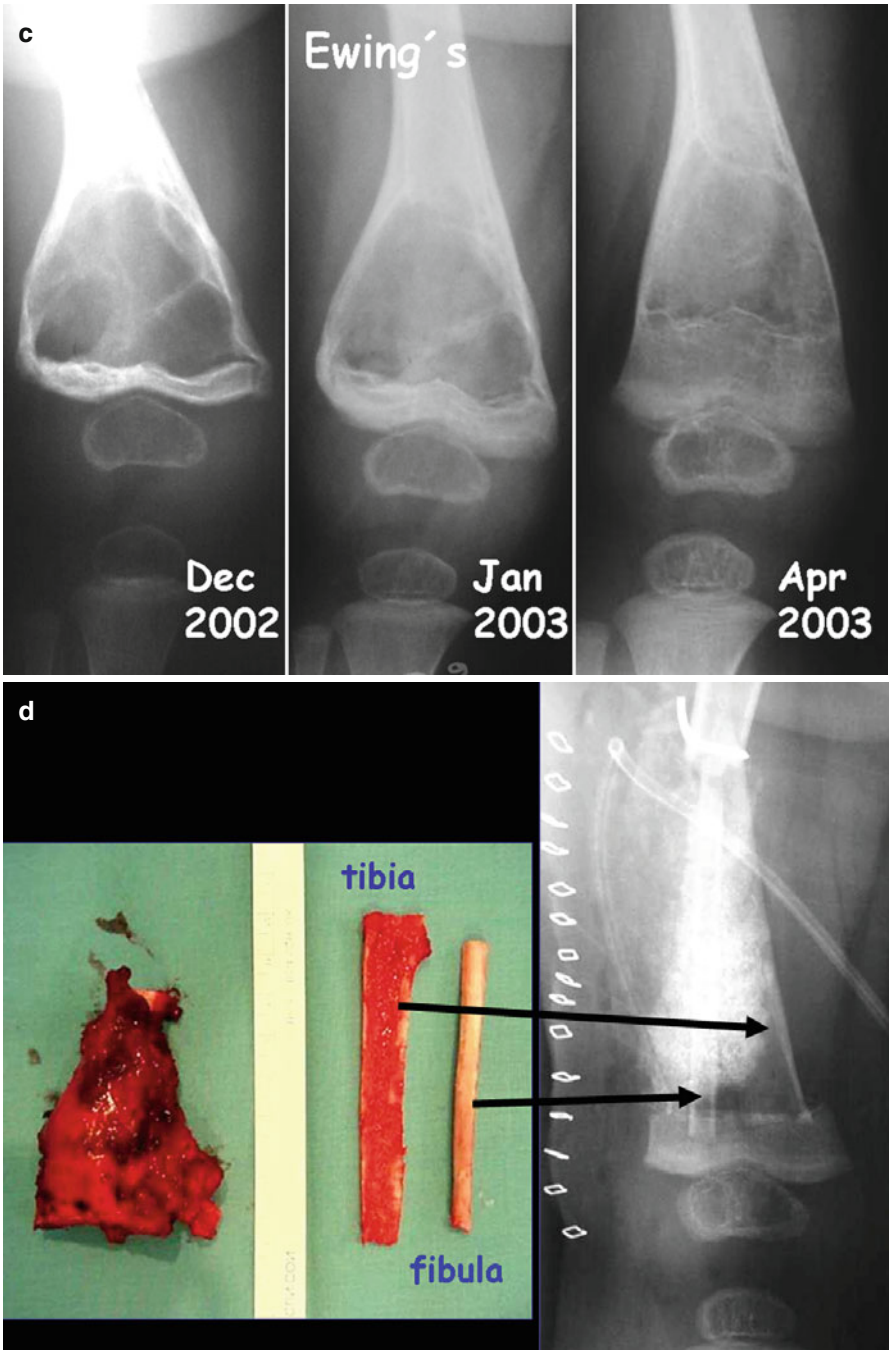


Fig. 13.1 (**a**) Ewing's sarcoma in the distal metaphysis of the femur of a 9-month-old baby. MRI shows is in contact with the physis. Most of our colleagues dealing with bone tumors would advise an amputation. (**b**, **c**) Neoadjuvant treatment was very succesful. Note the new bone formation from the distal femur growth plate. (**d**, **e**) Resection was performed through metaphyseal and diaphyseal osteotomies in order to preserve the joint. Autografts from ipsilateral fibula and tibia were used for reconstruction. (**f**) Follow-up: 13 years later, limb function is excellent (Reproduction from San-Julian et al. [14])



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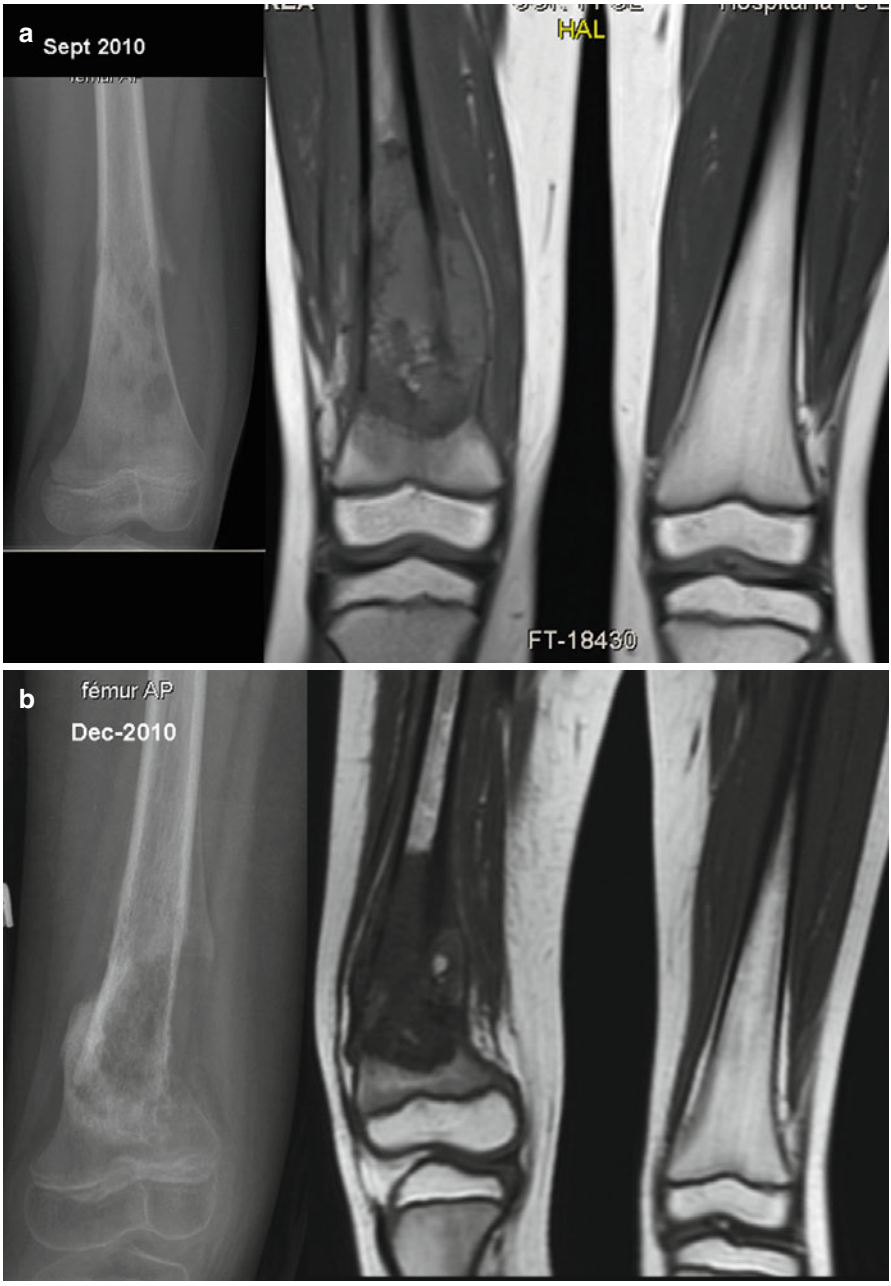

Fig. 13.2 (**a**) Osteosarcoma in the distal metaphysis of the femur of 8-year-old girl. (**b**) She started chemotherapy elsewhere and suffered a pathological fracture. (**c**) After neoadjuvant chemotherapy in our center. Note the growth in the distal femur growth plate that has displaced the tumor to the diaphysis. (**d**) Resection and reconstruction with an allograft. Good healing was obtained

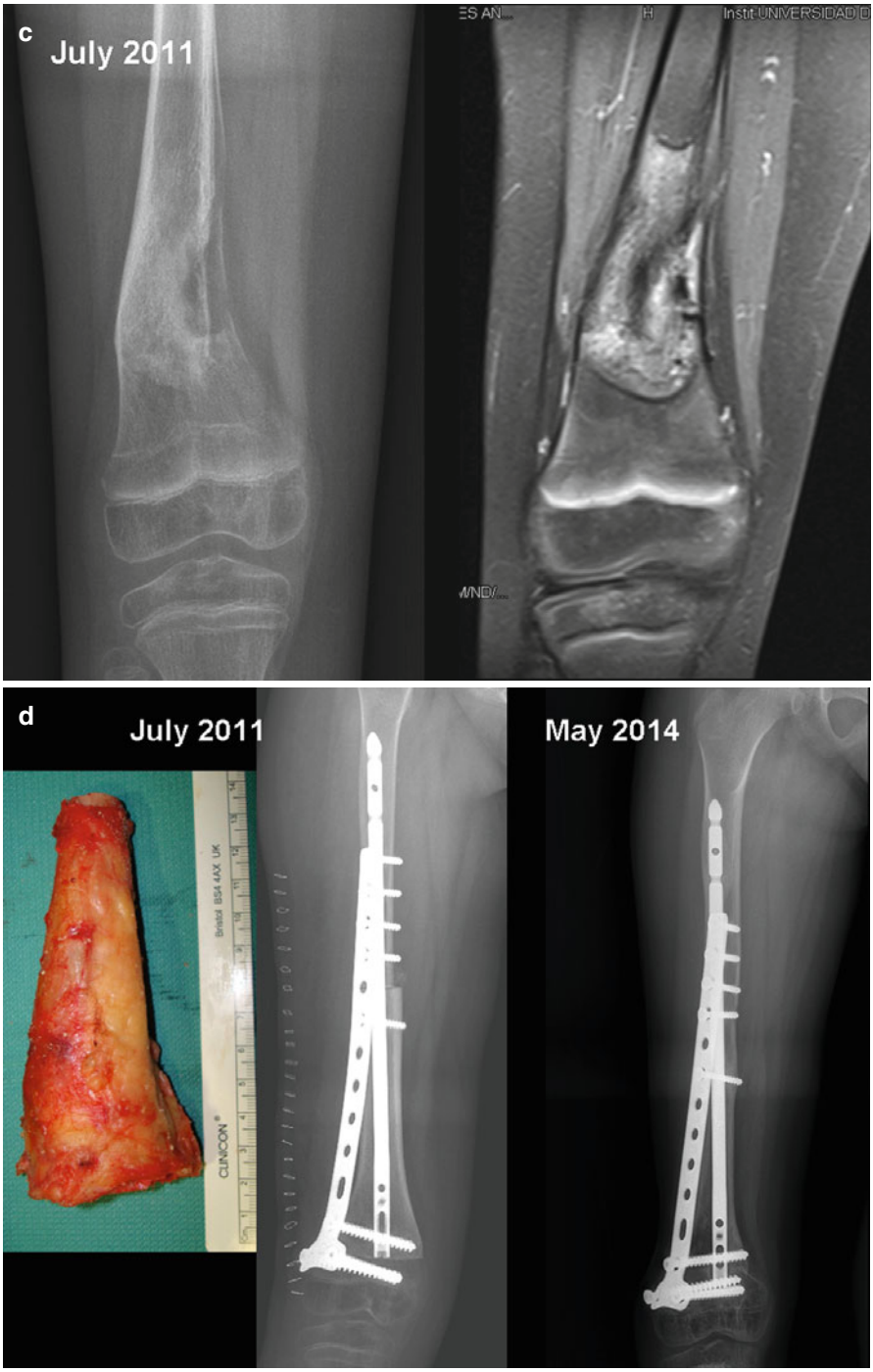

Fig. 13.2 (continued)

suggested subsequently. We have used intra-epiphyseal osteotomy in some cases, in which epiphysis could be preserved but physeal distraction was contraindicated (Figs. 13.3 and 13.4).

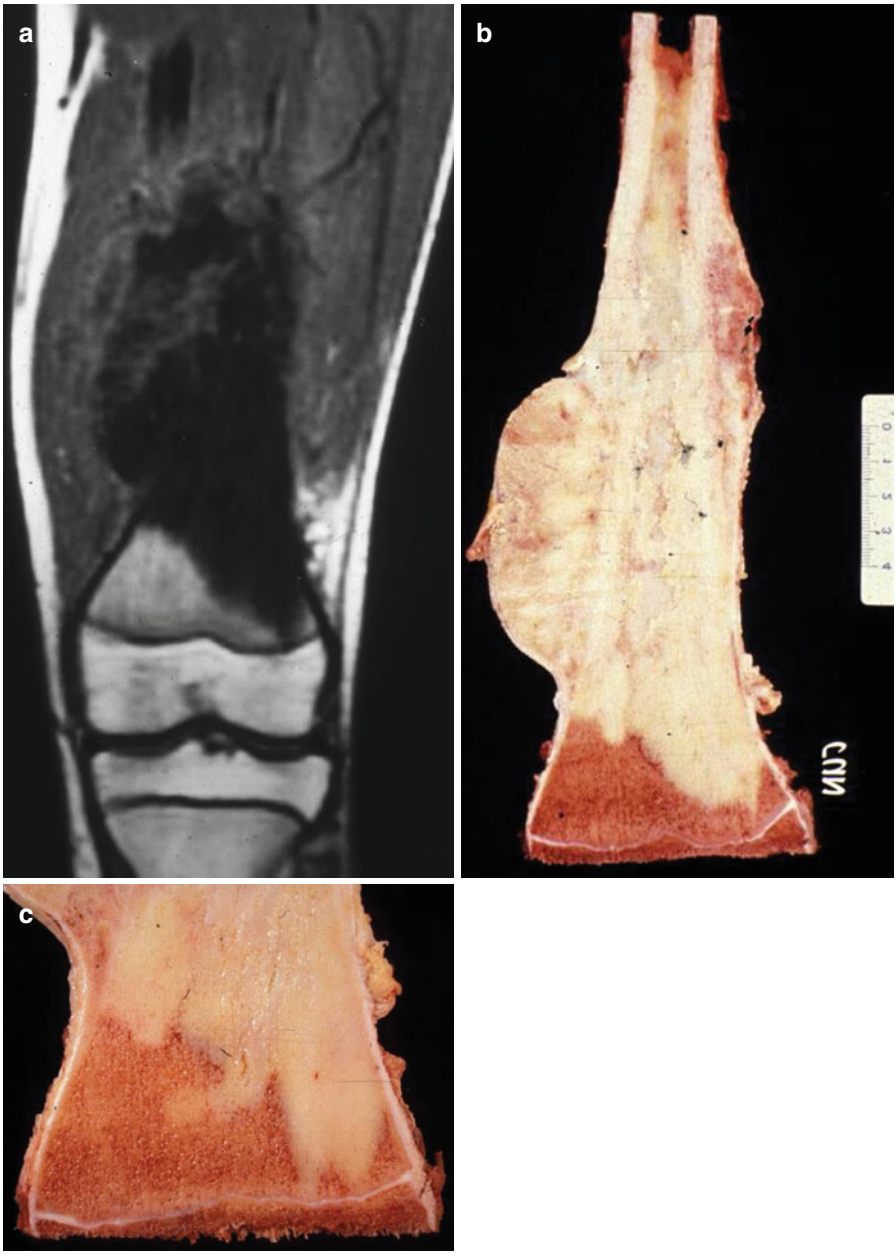

Fig. 13.3 (**a**) Osteosarcoma in the distal metaphysis of the femur of a 16-year-old boy. MRI shows the tumor in contact with the physis. This patient was treated in 1987. (**b**, **c**) Intra-epiphyseal osteotomy was performed in order to preserve the joint. Note that the growth plate is very thin

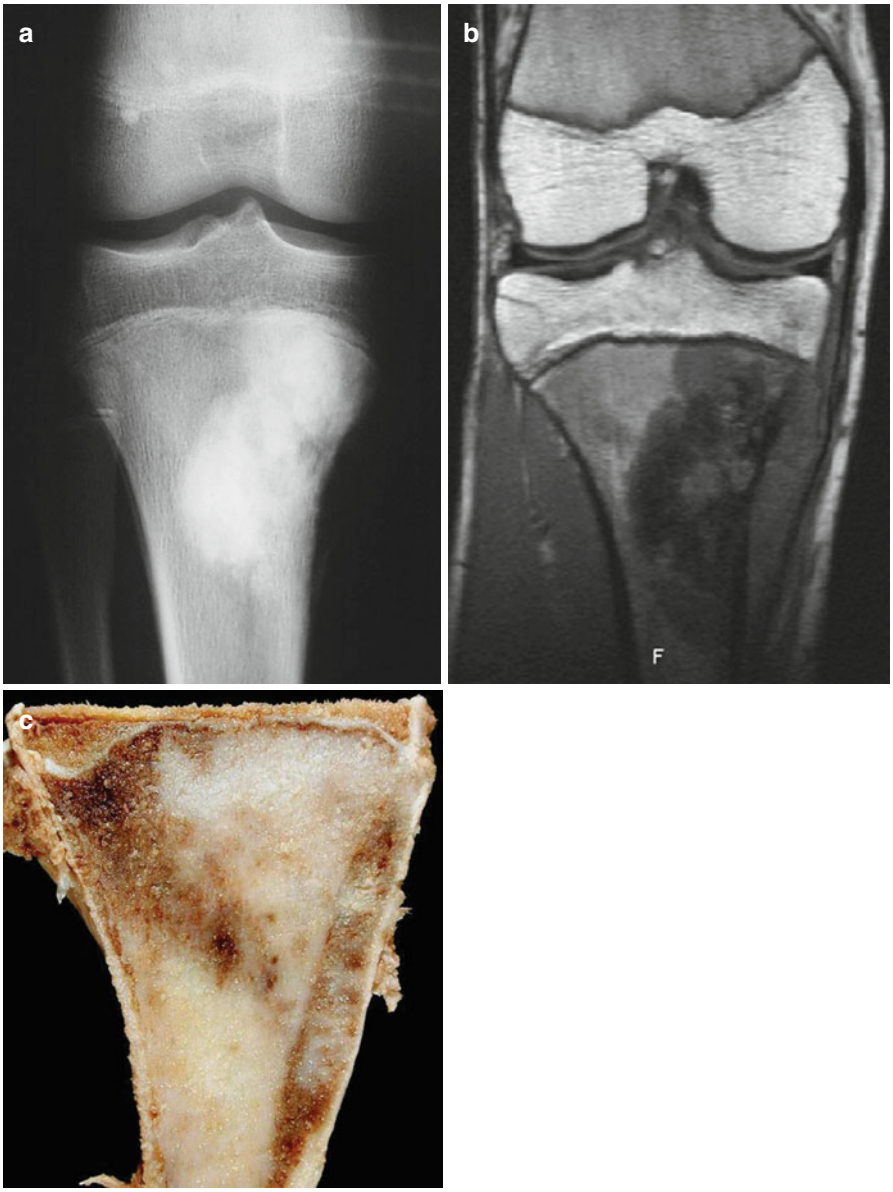

Fig. 13.4 (**a**, **b**) Osteosarcoma in the proximal metaphysis of the tibia of a 17-year-old boy. The tumor is in contact with the growth plate. (**c**) After careful consideration of epiphysiolysis before resection, we chose intra-epiphyseal osteotomy in view of the age of the patient. (**d**, **e**) Reconstruction with an intercalary allograft stabilized with both a plate and a nail

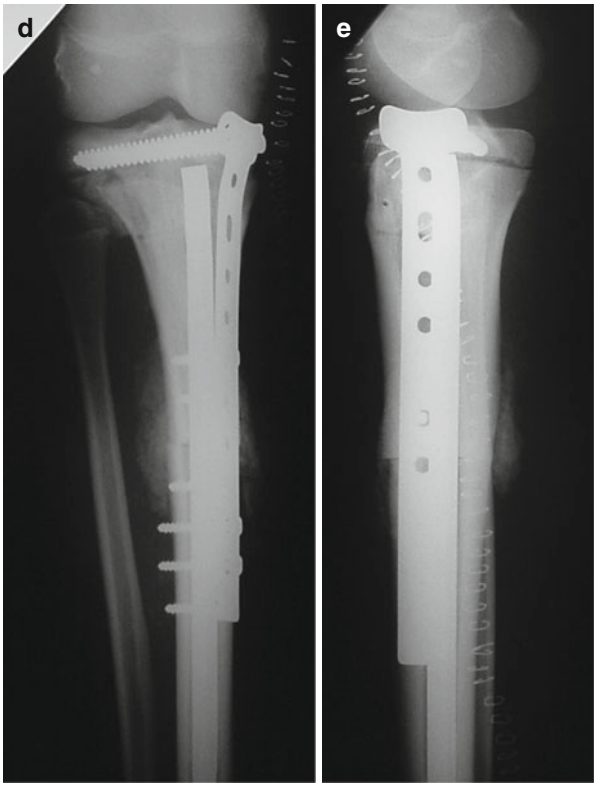

Fig. 13.4 (continued)

In the more recent reports of intra-epiphyseal osteotomy [2, 6–8, 10–12], the technique has been used mainly in proximal tibia locations. Tumor involvement of the physis is assessed by preoperative MRI. If intra-epiphyseal osteotomy is indicated, it is done under X-ray control in order to include the growth plate in the resected specimen. The residual epiphyseal bone segment is less than 2 cm thick and reconstruction is by a combination of vascularized fibula and allograft [3]. Authors report that local recurrence has not been observed to occur in the retained epiphysis [2, 13]. Other authors [1, 5] have employed metallic implants for reconstruction of the intercalary region, but follow-up is not yet long enough to know the long-term results with such implants. An epiphyseal osteotomy is fixed with small fragment screws.

In our opinion, the advantages of physeal distraction over intra-epiphyseal osteotomy are:

1. ***Safety***. The growth plate is not a flat surface – it has indentations and protuberances (Figs. 13.5 and 13.6) – and consequently intra-epiphyseal osteotomy could leave bits of tumor.
2. ***Easier resection***. Physeal distraction before excision of a metaphyseal bone tumor removes the need for metaphyseal osteotomy. Therefore, resection requires only one osteotomy – the diaphyseal one.

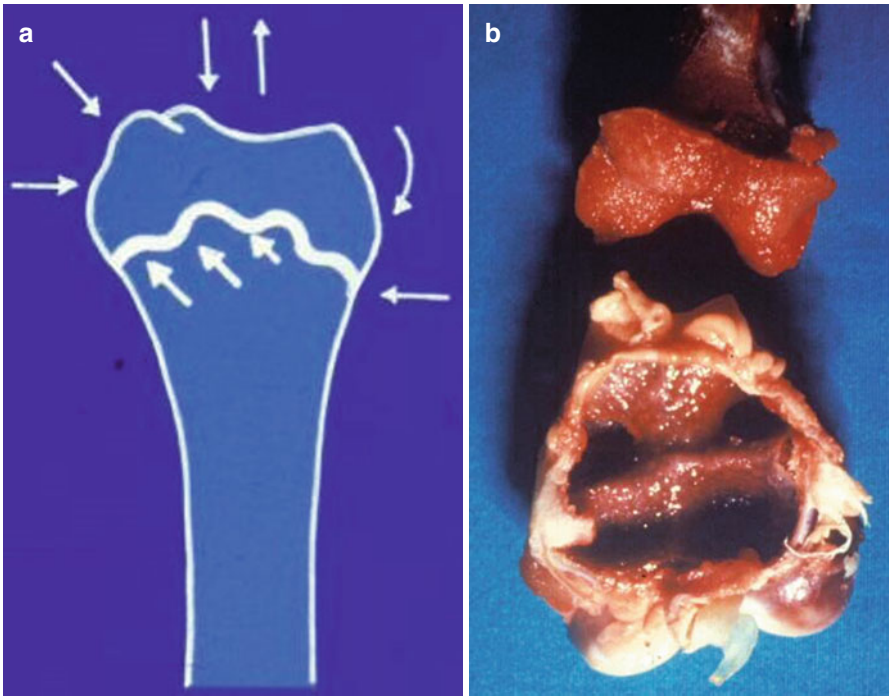

Fig. 13.5 (**a**) Because of the morphology of the growth plate, intra-epiphyseal osteotomy could leave tumor cells in the hollows of the surface. (**b**) Experimental epiphysiolysis in a lamb. Note the undulate appearance of the growth plate

Fig. 13.6 The morphology of the growth plate in the proximal humerus contraindicates, in our opinion, intra-epiphyseal osteotomy

3. ***Preservation of the whole epiphysis***. This has several advantages:

- Joint stability is better maintained because most ligaments, tendinous attachments, capsules, etc. are preserved (Fig. 13.7).

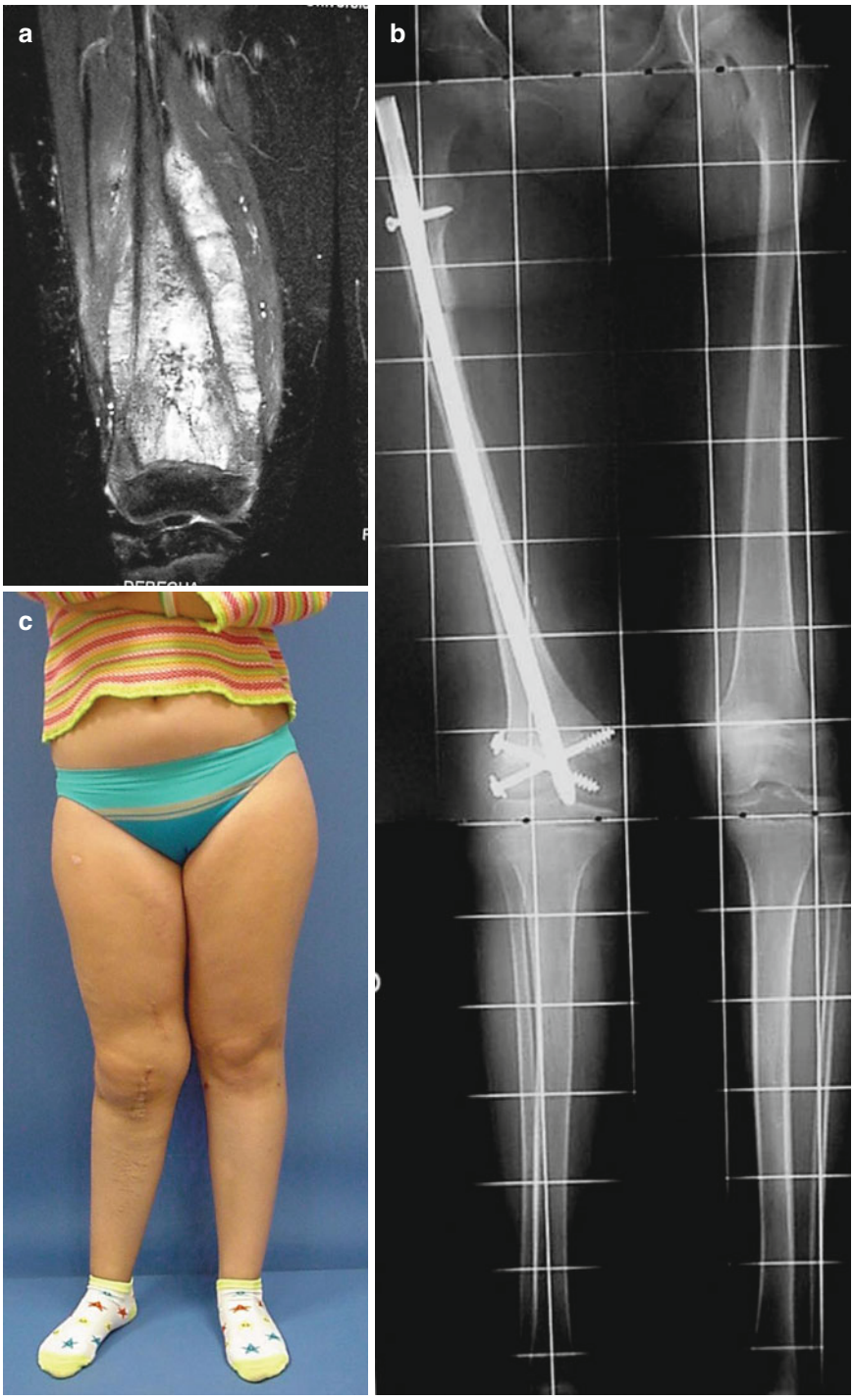

Fig. 13.7 (**a**) Osteosarcoma in contact with the whole physis. (**b**) Intra-epiphyseal osteotomy and reconstruction with an allograft. (**c**) Note the limb length discrepancy and the valgus instability

- Graft osteosynthesis is facilitated because the epiphyseal segment of bone is bigger.
- In distal femur locations, the *trochlea femoralis* is preserved. Intra-epiphyseal osteotomy implies the loss of part of the *trochlea femoralis* (Fig. 13.8), which can lead to a loss in knee function. Similarly, the patellar tendon attachment in the proximal tibia (Fig. 13.9) and the rotator cuff in the shoulder can be preserved.

4. ***Preservation of most of the growth plate***. Epiphysiolysis occurs through the layer of degenerative cells on the metaphyseal side of the growth plate. Therefore, most of the growth plate is retained, together with the epiphysis (Fig. 13.10). When the distraction procedure is performed at a rate of 1–1.5 mm/day, the retained physis remains active [4].

   We believe that intra-epiphyseal osteotomy is indicated in the following situations:

   - For resection of metaphyseal tumors with no involvement of the physis in which a pathological fracture has occurred. In such cases, unless the fracture heals during neoadjuvant treatment, physeal distraction is contraindicated because of the risk of distraction through the tumor instead of the growth plate (Fig. 9.9).
   - For resection of metaphyseal tumors in contact with part of the growth plate. In this scenario, intra-epiphyseal osteotomy could be an alternative to the standard Cañadell technique (see Chap. 10).
   - For resection of metaphyseal tumors without involvement of the physis, but in patients who are close to the end of growth: in such patients it is more difficult to achieve physeal distraction.

   Some example cases relating to the second and the third of these criteria are shown in Figs. 13.3 and 13.4.

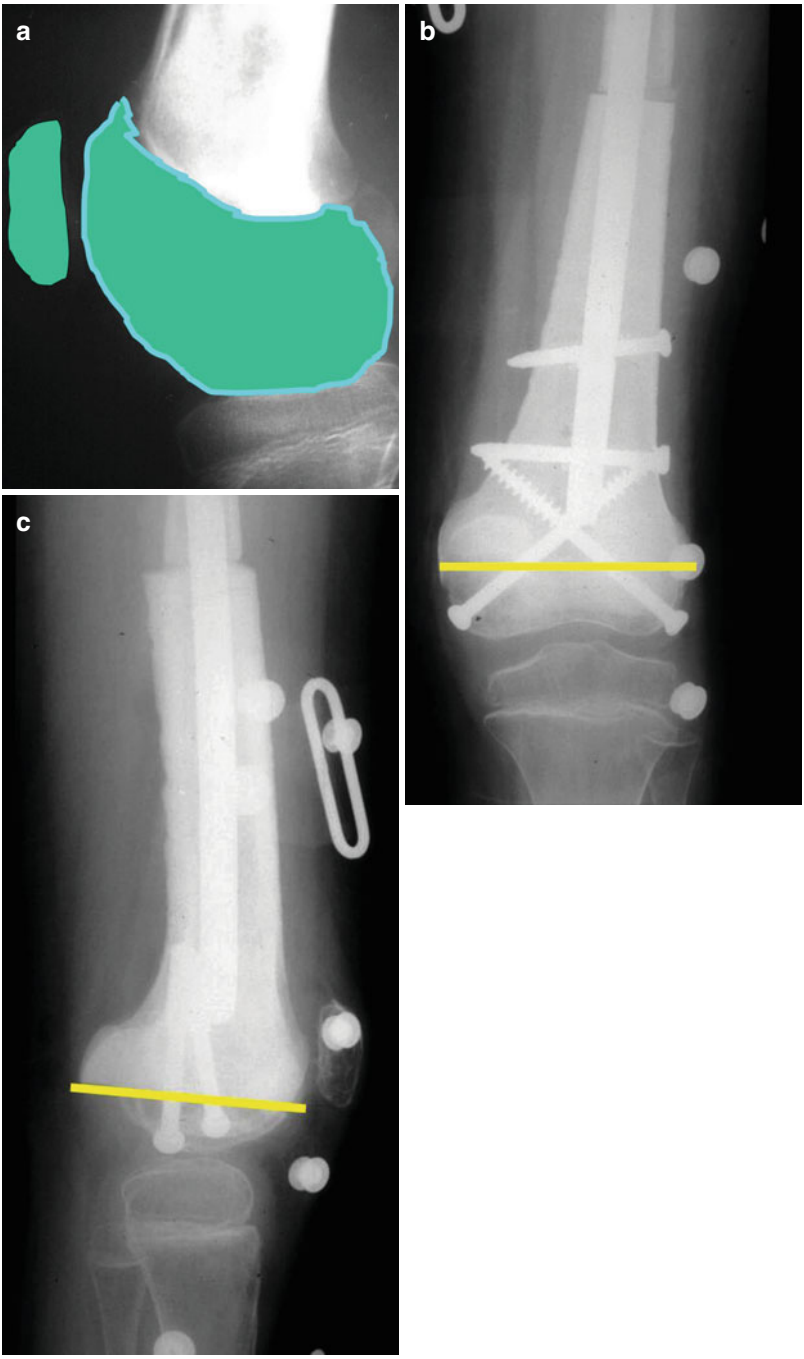

Fig. 13.8 (**a**) The growth plate extends to the cartilage of the condyles and trochlea femoralis. (**b**, **c**) The patient came to our hospital after pulmonary metastases had been detected by another institution. The previous X-rays were not available to us. Apparently, intra-epiphyseal osteotomy had been performed to preserve the joint. The functional result was poor because the osteotomy line cut the trochlea

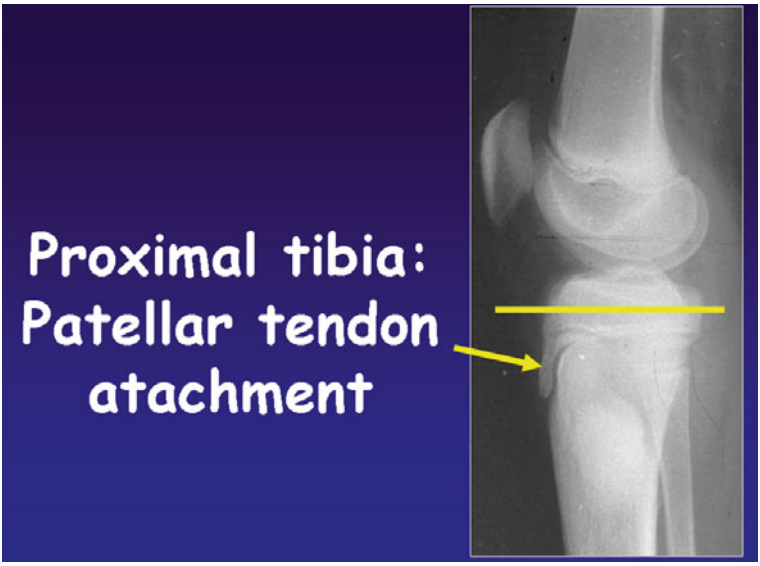

Fig. 13.9 Intra-epiphyseal osteotomy does not allow for preservation of the patellar tendon attachment

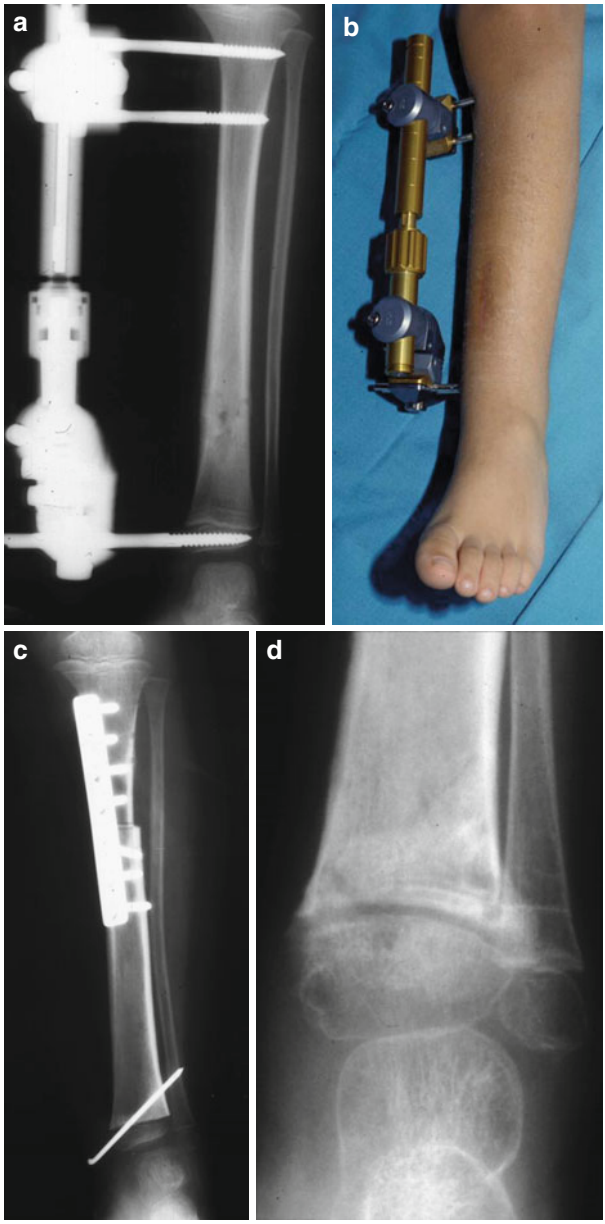

Fig. 13.10 (**a**, **b**) Physeal distraction before excision of a Ewing's sarcoma in the distal tibia of a 3-year-old boy. (**c**, **d**) The growth plate remains active after removal of the distal Kirschner wire

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