Surgery: Treatment of Oligometastatic Disease

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The treatment of the patient with bone metastases from prostate cancer is usually based on medical and radiation therapy [1–6]. Nevertheless, sometimes indication for surgery is present with:

- "Curative" aim: in case of solitary metastasis, onset after several years from the extirpation of the primary tumor in a healthy patient. In this case, surgery should extirpate the metastasis obtaining a wide margin.
- Palliative aim: in multimetastatic patient in case of
  - Impending and already-occurred fracture: quite rare indication considering that prostate metastasis is usually osteoblastic
  - Pain lesion
  - Spinal cord compression

The techniques can be classified in two main groups:

- Resections techniques, where a wide margin is aimed
- Stabilization technique, with an exclusively biomechanical value

They will be progressively shown basing on the bone segment where they are applied.

13.1 Vertebral Metastases Techniques

Approximately 70 % of all bone metastases are located in the spine, most frequently involved in the thoracic vertebras (60–70 %), followed by lumbar (15–30 %), and more rarely, cervical (less than 10 %). About half of metastatic spine patients experience multiple level lesions [7, 8].

To identify the best approach, the patient survival has to be estimated; in literature several scores are available [9], but, even if it underwent a recent criticism [10], the most used is the modified Tokuhashi score [11]. The authors individuated six parameters, including general condition, extraspinal bone metastasis, number of metastasis in the vertebral body, visceral metastasis, primary site, and severity of cord palsy. For each parameter a value between 0 and 2 is assigned, but for primary site, a value between 0 and 5 is assigned. Based on the total score, the patient is designated to one of three possible survival classes:

- Group I (score 0–8): survival inferior to 6 months
- Group II (score 9–11): survival inferior to 12 months
- Group III (score 12–15): survival superior to 12 months

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Tokuhashi suggested conservative or palliative treatment for patients in groups I and II, with multiple vertebral lesions. Excisional surgery was suggested for group III and patients in group II with single spinal metastases.

In case of prostate metastasis, the value to assign to primary site is 5 (?) because of its favorable intrinsic prognosis.

Drzymalski et al. [12], in a study on 333 patients affected by spinal metastasis, evidenced as the median survival after diagnosis of spinal metastasis was 24 months, but among the 28 patients with a solitary vertebral metastasis, the median survival was 55.9.

A higher prostate-specific antigen (PSA) level at diagnosis of metastasis, the presence of additional metastasis at diagnosis of spinal metastasis, and a long free of disease time between the diagnosis of prostate cancer and spinal metastasis resulted as independent prognostic factors ($p=0.0001$).

13.1.1 En Bloc Vertebrectomy

En bloc vertebrectomy is a high-demanding surgery with a high complication rate so indication has to be reserved just for selected cases [9]. It should be performed in case of solitary lesion, occurred in healthy patient at several years from the extirpation of the primary tumor.

Surgery is usually performed by a posterior approach for the dorsal spine and upper lumbar spine, whereas a preparatory anterior approach is advisable for lower lumbar levels to divide vascular bundles from the mass and the near-spine elements (Fig. 13.1).

Cervical en bloc vertebrectomy is technically more difficult so no case is evident in literature for metastatic patients.

13.1.2 Stabilization and Intralesional Surgery (Curettage)

In case of risk of fracture, or in case of spinal cord compression, patients enrolled in group II of Tokuhashi (intermediate survival) decompression and/or stabilization could be a good solution.

In 2012, Crnalic et al. [13] identified a new specific score for patient with cord compression from prostate cancer; the items include hormone status of prostate cancer, Karnofsky performance status, evidence of visceral metastasis, and preoperative serum prostate-specific antigen (PSA). They identified three specific prognostic groups corresponding to different score:

- Group A (score 0–1), with a median survival of 3 months
- Group B (score 2–4), with a median survival of 16 months
- Group C (score 5–6), where more the half part of the patients were alive at publication of their experience

Patients with a score higher than 2 are more suitable to undergo surgery in case of spinal cord compression.

Stabilization alone is rare, considering the high frequency of osteoblastic lesions; nevertheless it can be fundamental in case of spinal cord compression; indeed, the following decompression can cause an iatrogenic instability.

Decompression can be performed both from anterior and posterior approach basing on the metastasis-specific localization, the spine level, and the surgeon expertise. In the thoracic spine, decompression should be performed from an anterior approach because the presence of the spinal cord could make difficult and effective decompression from a midline posterior access; nevertheless, cutting roots could be useful to have access to the vertebral body from behind.

At lumbar levels the presence of cauda equina allows an easier access to the anterior metastatic bodies.

Posterior stabilization is the most commune; it is performed by posterior midline incision or also by minimally invasive approach consisting in little incisions corresponding to the pedicles necessary for the screw insertion through the pedicle [14].

Several instrumentations are commercially available, but nowadays carbon fiber-reinforced rods should be preferred [15]. Indeed, they should allow a more effective adjuvant radiotherapy because it is characterized by a lower level of artifacts.

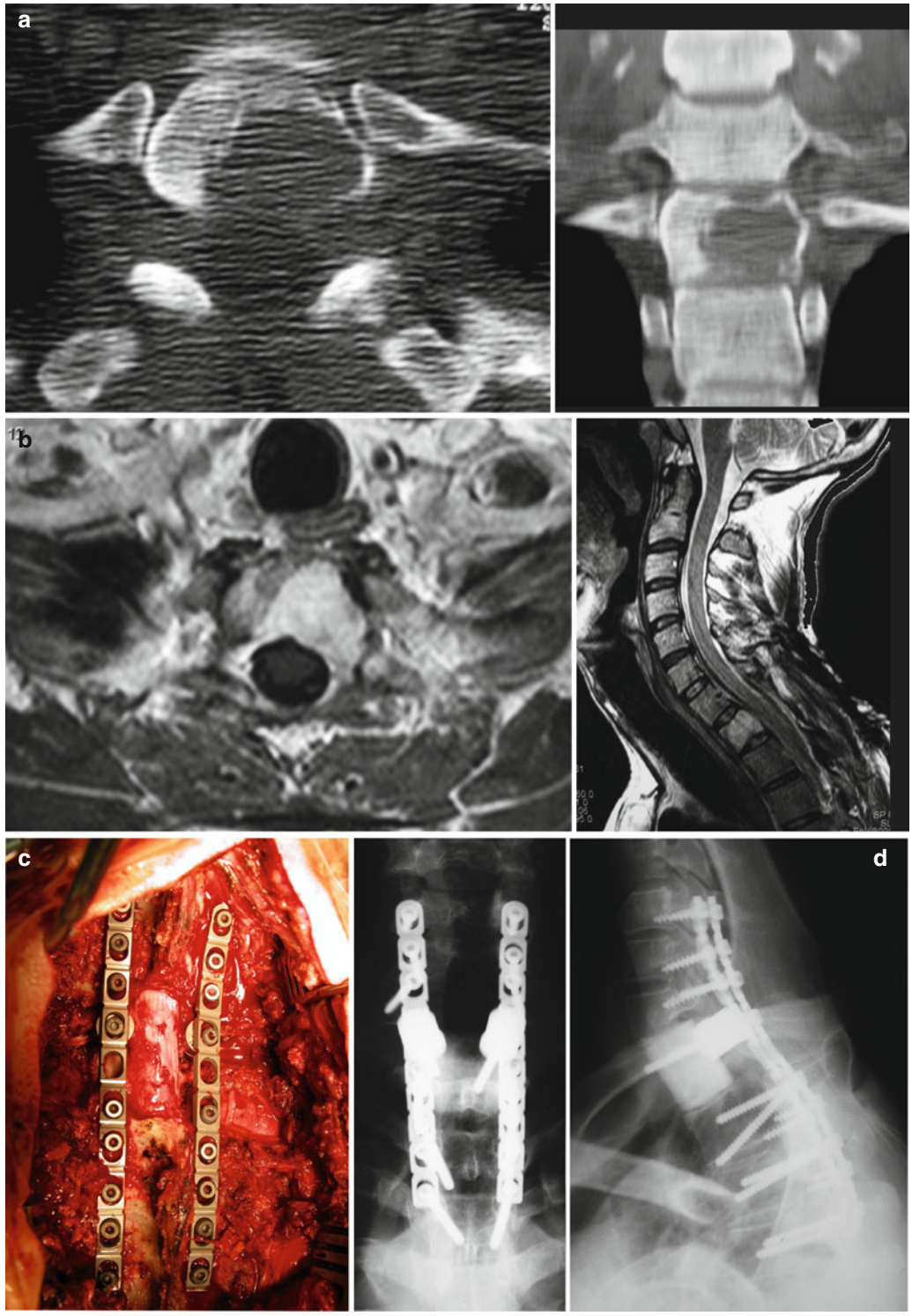

Fig. 13.1 A D1 solitary osteolytic metastasis; the 56-year- old patient underwent en bloc vertebrectomy and reconstruction with homoplastic diaphysis segment filled with the autoplastic morcellized bone, plates, and screws; (**a**) preoperative CT scan showing an osteolytic lesion in the D1 vertebral body, (**b**) preoperative MRI, (**c**) intraoperative imaging showing posterior stabilization, and (**d**) a 2-year follow-up X-ray

The artifacts at CT scan blind some areas in the surrounding tissue, introducing diffraction and refraction phenomena, so the actual dose administered to the tissues becomes unpredictable.

Anterior stabilization can be done with a body cage alone or with anterior plating and screws; also in those cases, carbon fiber cages should be preferred [16, 17].

13.1.3 Augmentation Technique

Cement plasty (Kyphoplasty, vertebroplasty, vesselplasty): these techniques are very commune in osteoporotic fractures; nevertheless they can have indication also in metastatic lesion.

In case of metastatic spinal fracture, they can be able to stabilize it in a minimally invasive way, even if attention has to be paid for possible posterior cement or tumor migration.

Indeed, spine metastasis from prostate cancer difficultly causes body fracture, but they can cause important not responsive pain that can be effectively treated with these techniques [18, 19].

The procedure can be performed by monoportal or biportal transpedicular approach basing on the specific necessity of stabilization; the integrity of the posterior body wall is essential for safety performing the procedure (Fig. 13.2).

13.2 Femoral Metastases Techniques

Proximal femur is the most commune site of metastasis, after the spine [20].

Even if the treatment of these lesions should not modify directly the survival from a biological/oncological point of view, the patient constricted to bed because of risk of fracture is exposed to complications that could interfere with medical therapies decreasing survival [21, 22].

Otherwise survival estimation is important as in the other sites for the best therapeutic strategy, but in case of metastases located in the limbs and moreover in the proximal femur, an important problem is to value the fracture risk [23].

Several systems are available, but the most used is the Mirel's classification [24]; it identifies four items: location of the metastasis, its nature and radiographic appearance, its size related to the diameter of the entire segment, and the presence of pain.

Each item is scaled from 1 to 3.

When the total score is 7 or less, observation and radiation therapy is advisable; when it is 9 or more, prophylactic fixation is suggested; if the score is 8, the indication is uncertain, and it should be valued basing on clinical conditions as well.

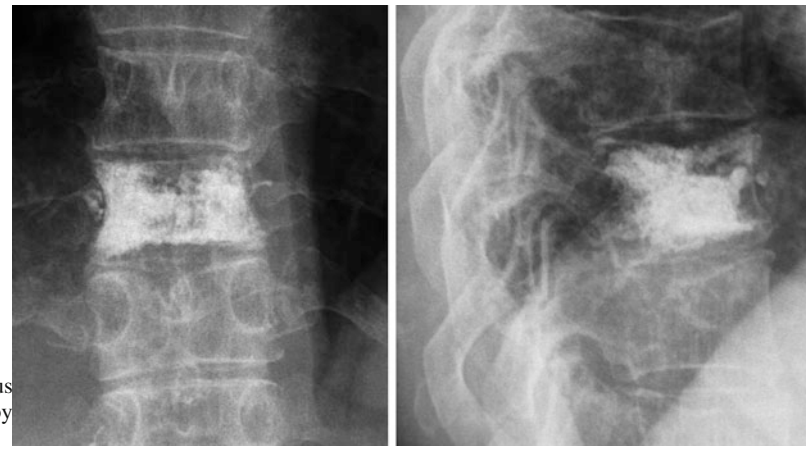

Fig. 13.2 A percutaneous vertebroplasty performed by biportal approach

	1	2	3
Location	Upper extremity	Lower extremity	Intertrochanteric
Radiographic appearance	Blastic	Mixed	Lytic
Size	<1/3	1/3–2/3	>2/3
Pain	Mild	Moderate	Severe and functional

The metastasis of prostate cancer is usually osteoblastic so surgical indication is usually less frequent than metastases from other primitive tumors.

13.2.1 Proximal Femur Resection and Prosthesis Reconstruction

In case of solitary lesion, in a healthy patient after several years from the primary tumor eradication, wide surgery has to be preferred. This means performing a resection of the proximal part of the femur which is extended distally about 2 cm distally to the inferior edge of the disease.

Reconstruction is performed with a modular prosthesis which is assembled to reach the resection size [25–27]; the intramedullary stem should be as long as possible to reinforce the entire femur, stabilizing the segment also in case of further distal metastasis onset. When the greater and the lower trochanters are not involved, they should be spared to maintain the muscular insertion (Fig. 13.3). The psoas muscle is the most important stabilizer.

An ideal modular prosthesis should allow a minimal resection, arming the entire femur when necessary; it should be cemented to assure the grip even in case of further metastasis.

Resection has to be preferred also in case of multimetastatic patients when the disease extends also in the head and femoral neck; intramedullary nailing should complicate with proximal screws cut out.

Fig. 13.3 A postoperative X-ray showing a hip prosthesis where the greater and lower trochanters and their muscular insertions were spared

13.2.2 Diaphysis Resection and Reconstruction

The indication to resection in the diaphysis is the same of that of the proximal femur. Obviously it is very rare. Reconstruction can be performed with a diaphyseal prosthesis (Fig. 13.4) or a homologous diaphysis filled with cement and stabilized with plate and screws [28].

13.2.3 Intramedullary Stabilization

Intramedullary stabilization is the mainstay treatment in case of fractures or impeding fractures of

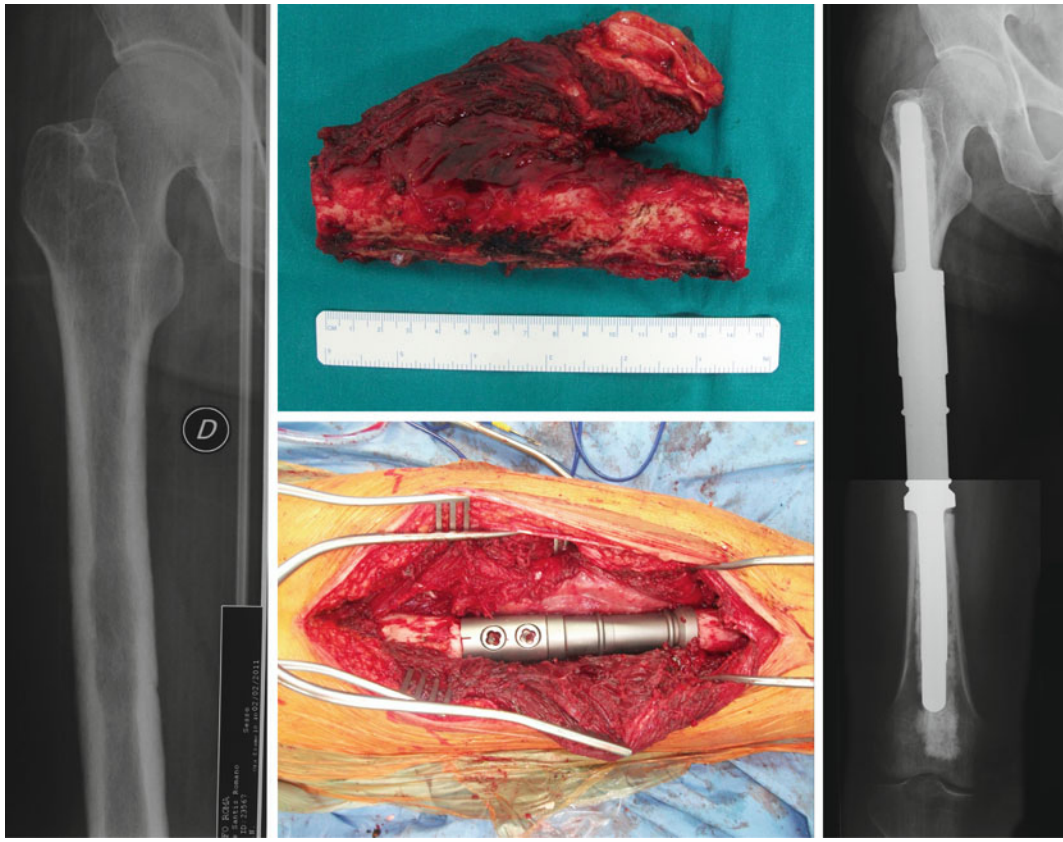

Fig. 13.4 A solitary lesion of the femur diaphysis *on the left*; in the upper center figure the resected specimen and in the lower center picture a diaphyseal prosthesis; *on the right* the postoperative X-ray

lesions located from the trochanteric area until the distal diaphysis in multimetastatic patient [29]. Surgery aims to allow weight bearing as soon as possible so that the patient can undergo chemotherapy.

The nail must be always long and stabilizes the entire femur; it has to be distally locked, and a cervical screw must be always present even in case of diaphyseal metastasis considering the high frequency of femoral neck lesions: the screw in the femoral head will stabilize the femur also in case of successive metastasis (Fig. 13.5) even if a recent study sustains that it is not always necessary [30].

Intramedullary nailing has exclusively a biomechanical role; the treatment has to be completed by adjuvant radiotherapy; in case of not radiosensitive tumors, a wide resection could be indicated also in multimetastatic patients because of the inefficiency of adjuvant therapy.

Considering that, carbon fiber-reinforced nails are to be preferred in case of diaphyseal metastasis (Fig. 13.6); unfortunately, a carbon fiber nail with a cephalic screw is now not commercially available.

Also other cytoreductive technique can be associated as cryotherapy, radio-frequency thermoablation, or embolization [31]. Weight bearing has to be valued for every specific case.

13.2.4 Distal Femur Resection and Prosthesis Reconstruction

When metastasis is located in the distal part of the femur, where it is not possible to stabilize the

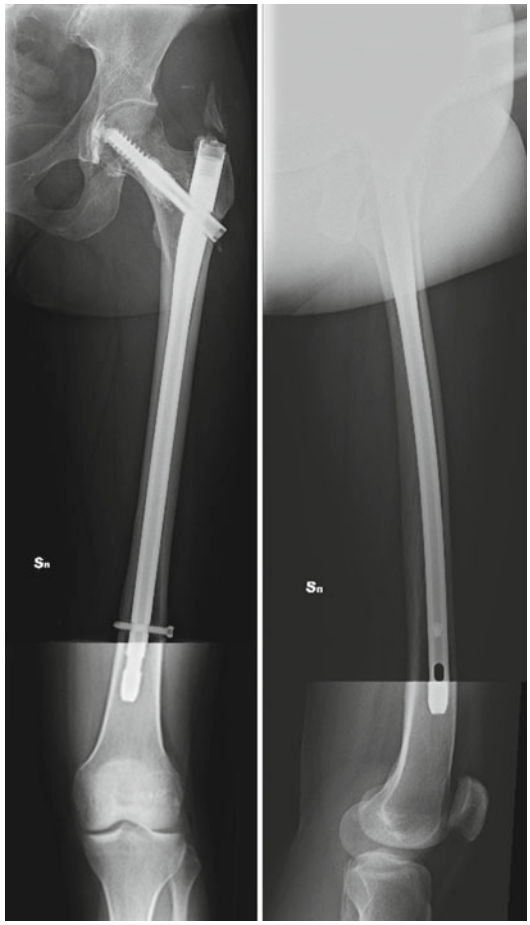

Fig. 13.5 In intramedullary nailing for an impending fracture of the proximal femur. The proximal neck screw and the extension for all the femur protect the patient in case of further metastasis as well

Fig. 13.6 A carbon fiber nail inserted in an impending fracture

segment with an intramedullary nailing, resection and prosthesis reconstruction is necessary. Nevertheless indication is very rare.

13.3 Tibial Metastases Techniques

13.3.1 Proximal Tibial Resection and Prosthesis Reconstruction

Rarely, in case of lesions located in the proximal part of the tibia, resection and prosthesis reconstruction can be indicated, moreover in case of single metastasis.

In case of multimetastatic disease, minimally invasive technique as cement augmentation could be preferred to allow weight bearing with a minimal impact.

13.3.2 Intramedullary Stabilization

Intramedullary stabilization is the most frequent operation performed on the metastatic tibia [32]. As in the femur, the nail has to be long and locked distally (Fig. 13.7). Weight bearing has to be valued for every specific case.

Fig. 13.7 A locked tibial nail for an extensive diaphyseal prostate metastasis

13.4 Humerus Metastases Techniques

Indications for surgery in superior limbs are very rare in prostate cancer metastases because the risk of fracture is very low, because of the lower load than inferior limbs, and because of the osteoblastic nature of the lesions [33].

13.4.1 Proximal Humerus Resection and Prosthesis Reconstruction

In case of solitary lesion of the proximal femur, onset after years from the primary tumor eradication in a healthy patient, wide resection and prosthesis reconstruction is indicated (Fig. 13.8).

The reconstruction possibilities are two: the standard prosthesis and the inverted (?) prosthesis. In the first case, the prosthesis mimics the normal anatomy; in the inverted prosthesis, the concave surface is on the humeral part, whereas the convex side is on the scapular side. The second one is preferred when it is possible to spare the deltoid muscle and circumflex nerve so that abduction could be still possible even after wide resection [34].

13.4.2 Diaphysis Resection and Reconstruction

Indication of wide resection in humeral diaphysis is the same with that in the proximal humerus.

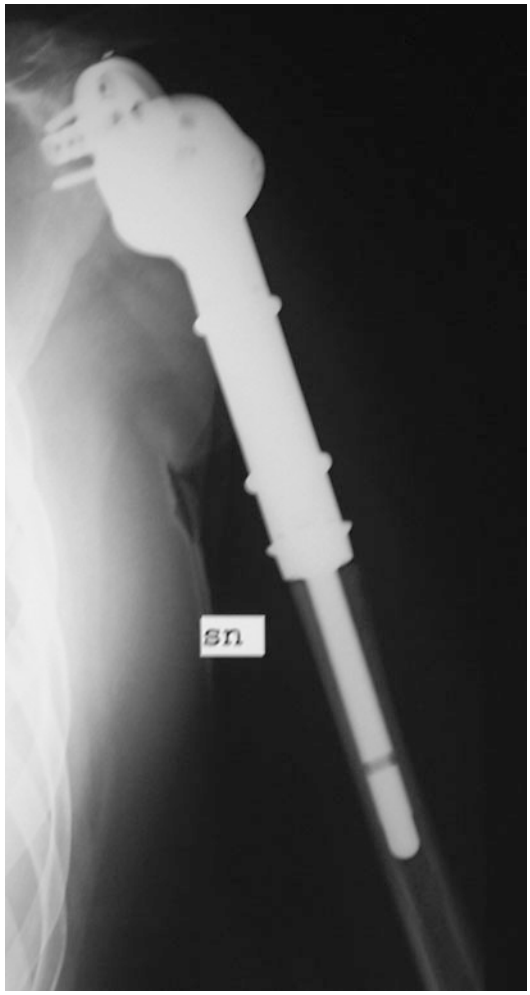

Fig. 13.8 Postoperative X-ray showing reverse prosthesis reconstruction after proximal humerus resection

Reconstruction can be performed with diaphyseal prosthesis or by homograft.

13.4.3 Intramedullary Stabilization

Lesion located in the proximal humerus and in the diaphysis in multimetastatic patients can be treated by intramedullary nailing (Fig. 13.9) [35].

Nevertheless, indication is very rare in prostate cancer, especially considering the prevalent osteoblastic nature of the lesions. Several nailing systems are commercially available; in the humerus, besides carbon-fiber nails is available also a liquid nailing system constituted by a monomer which becomes hard when exposed to UV light; then it can be drilled and screwed to stabilize fracture and impending fracture, allowing adjuvant radiotherapy (Fig. 13.10) [36].

13.5 Scapular Metastases

Scapular metastases from prostate cancer are quite commune. In case of solitary lesions, indication for wide resection has to be valued basing on clinical conditions. In multimetastatic patient no risk of fracture is present, so minimally invasive techniques should be preferred; sometimes, a partial or a total scapulectomy can be indicated also in multimetastatic patients, for big size lesion at risk for skin ulceration.

Reconstruction is not always performed, moreover in case of total scapulectomy when rotatory cuff muscles are not preserved (Fig. 13.11).

No modular prosthesis is commercially available so reconstruction has to be performed using homograft or custom-made [37].

13.6 Pelvic Metastases Techniques

The pelvis is a frequent site for metastasis, but usually they do not require surgical treatment because they are often stable, mostly in case of prostate metastases.

Indications for resection have to be valued case by case considering that resection surgery can be very difficult in case of lesions located in the acetabular area but quite easy if located in the wings. Solitary lesion onset in a healthy patient several years after resection could undergo wide resection.

In case of osteolytic metastasis in the acetabular roof, minimally invasive cement augmentation could be helpful to allow an early weight bearing (Fig. 13.12) [38, 39].

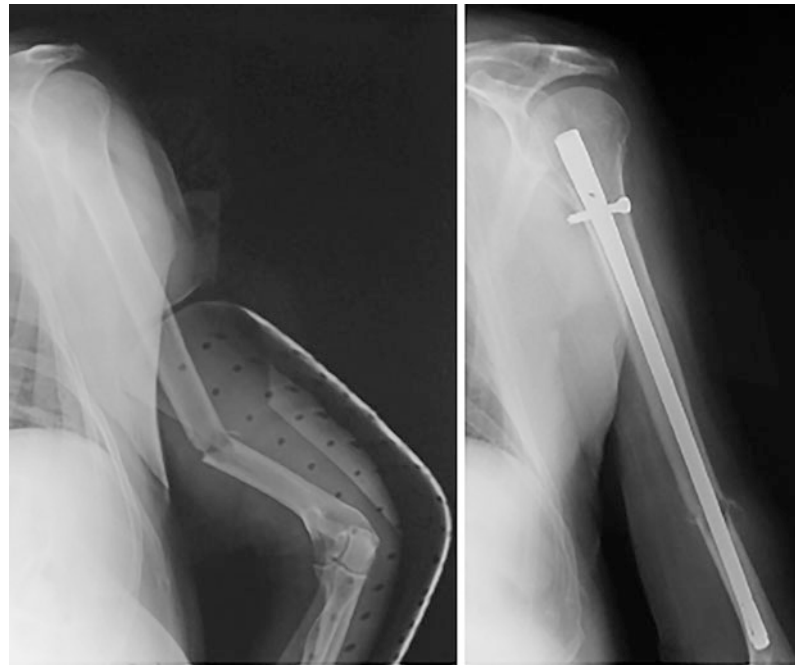

Fig. 13.9 Postoperative X-ray showing intramedullary humerus stabilization

Fig. 13.10 A liquid nail used to stabilize an impending fracture of the humerus; a soft shell is inserted inside the medullary canal, then it is filled with a monomer: the exposition to a UV light causes polymerization and its hardening

Fig. 13.11 A postopera-tive X-ray after partial scapulectomy for solitary metastasis of prostate cancer

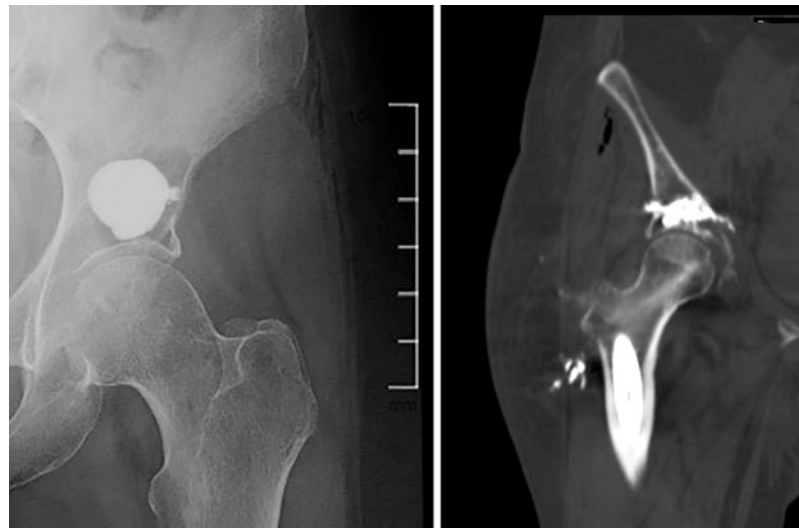

Fig. 13.12 On the left is an acetabuloplasty performing with a system which partially maintains inside the cement; on the right the direct filling of the acetabular is in the roof

13.7 Complications

13.7.1 Bone Explosion (During Intramedullary Stabilization)

The bone affected by prostate cancer metastasis is harder than normal but less elastic as well. In case of intramedullary stabilization, particular attention has to be paid during the reaming; indeed, the nail should be inserted inside the femur without effort. Hammering the nail can cause the femur fracture, as shown in the picture (Fig. 13.13); wiring the fracture is useless because it will hardly heal. A nail removal, resection of the proximal femur, and prosthesis reconstruction were then scheduled.

Fig. 13.13 A failure surgery. In this case the nail was hammered inside the medullary canal, but this caused its explosion; the surgeon unsuccessfully tried to stabilize it with wiring. The patient has to undergo further surgery of resection and prosthesis reconstruction

13.7.2 Corticalization of the Trabecular Bone (Cutter Rupture) (Fig. 13.14)

Prostate metastases are osteoblastic in most cases; it is not rare to see total or subtotal substitution of a segment as shown in the following picture. Cutting and drilling the bone can be very difficult, and a right strategy has to be valued every time before surgery. In the last square, it is possible to note the cutter broken inside the medullary corticalized (Fig. 13.14). In that case a little fenestration was done in the femur for its removal.

13.8 Adjuvant Techniques

The minimally invasive cytoreduction techniques play an important role in case of prostate cancer, because in most cases, no mechanical instability is present, and they can guarantee a good effect, particularly on the pain.

Fig. 13.14 A subtotal substitution of the normal bone from prostate cancer metastases. In this case, resection was performed just for mechanical problem, but the medullary drilling was problematic because of the hardness of the segment so that the cutter broke inside

Cryotherapy and radio-frequency thermoablation are probably the most commune; they are less invasive, and the treatment can be completed with adjuvant radiotherapy [31].

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