Percutaneous Bone tumor management

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A. GANGI MD, PHD, S. GUTH MD, J.P. IMBERT, X. BUY, J.L. DIETEMANN MD, C. ROY MD.

Department of Radiology, University Louis Pasteur Strasbourg

Any questions or to submit cases please send us the mail at following addresses

E-mail : Afshin Gangi - E-mail : Stephane Guth

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1) Introduction

Surgical resection is considered the only potentially curative option for primary and secondary malignant bone tumors. However, in secondary bone tumors only few patients are surgical candidates and some benign bone tumors like osteoid osteoma are the perfect indication of percutaneous management. Four existing minimally invasive techniques for the treatment of primary and secondary bone tumors-alcoholization (ethanol ablation), cementoplasty, radio frequency ablation, and laser photocoagulation are reviewed and debated. Aspects of each technique including mechanism of action, equipment, patient selection, treatment technique, and recent patient outcome are presented. The benefits and limitations of each technique are discussed.

2) PERCUTANEOUS TECHNIQUES :

- Alcoholization
- Cementoplasty
- Thermal ablation
  - Radio frequency
  - Laser photocoagulation

3) ALCOHOLIZATION

Worldwide, alcoholization or ethanol ablation is probably the most accepted minimally invasive method of treating primary malignant hepatic tumors. The ethanol is widely used in pain management (neurolysis) and ablation of osteolytic bone metastases. Radiation therapy, which may prevent tumor growth, usually results in partial or complete pain relief, with most patients experiencing some relief within 10-14 days. If conventional anticancer therapy is inefficient and high doses of opiate analgesics are necessary to control pain, alcoholization provides an alternative therapy.

Mechanism

Within cells, ethanol causes dehydration of the cytoplasm and subsequent coagulation necrosis, followed by fibrous reaction. Within vessels, ethanol induces necrosis of endothelial cells and platelet aggregation, thus causing thrombosis and tissue ischemia

Equipment

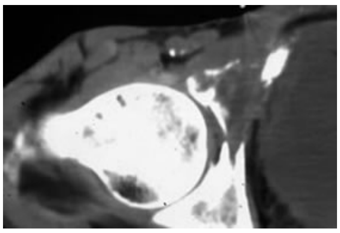
The materials used

- sterile ethanol 95%
- a syringe
- connecting tube
- contrast media
- and a 21.5-gauge spinal needle

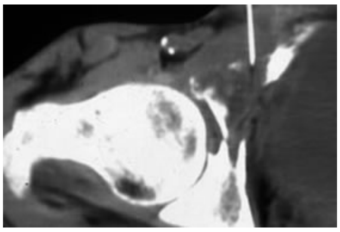
Fig 1 : Photograph shows alcoholization equipment, which consists of a syringe, sterile 95% ethanol, and a 21.5-gauge spinal needle, contrast media, lidocaine

Patient Selection and Technique

The size and shape of the induced necrosis with ethanol is not always reproducible. It varies with the degree of vascularization, necrosis and tissue consistency. That's the reason why we use ethanol in palliative management of painful osteolytic bone metastases. After delineation of tumor location and size on contiguous pre- and post-contrast CT scans, the optimal puncture site and angle were defined. Contrast-enhanced CT was performed to determine the necrotic part of the tumor.



alcoholization of painful osteolytic bone metastasis



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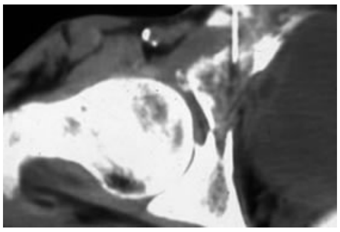
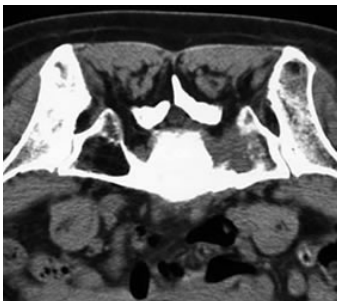
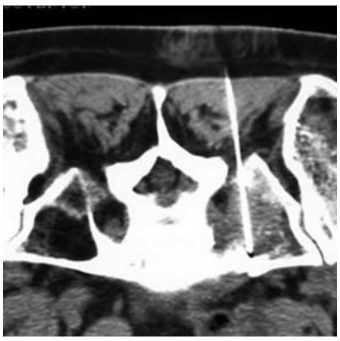


alcoholization of painful osteolytic bone metastasis injection of 4 ml ethanol

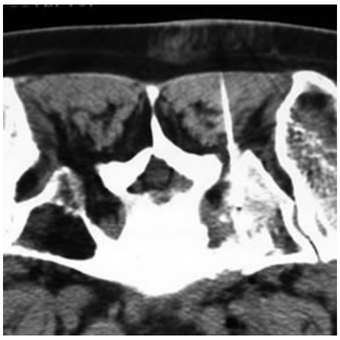
Following local anesthesia (Lidocaine 1%) a 21,5-gauge needle is placed in the tumor. Initially, contrast medium 25% diluted is injected into the lesion. The distribution of contrast media within the tumor is imaged by CT and predicts the diffusion of ethanol in the lesion. In cases in which diffusion of the contrast medium extends beyond the tumor boundaries, particularly when reaching contiguous neurologic structures, the procedure is discontinued.



Painful bone metastases (lung cancer)



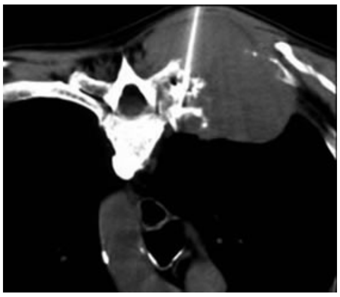
needle placement



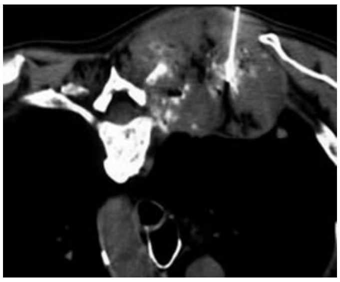
Injection of 5 ml of ethanol under neuroleptanalgesia. No leak into the foramina.

Depending on tumor size, 3 to 25 ml of 95% ethanol are instilled into the tumor. In large tumors, alcohol is selectively instilled into regions considered to be responsible for pain, usually the periphery of the metastases and osteolytic areas. After injection of three ml of alcohol, CT again evaluates the distribution in the tumors. If the distribution of ethanol is uneven within the tumor (particularly in large metastases), the needle is repositioned in regions of poor diffusion and the injection is repeated.

Large painful metastases (lung cancer)



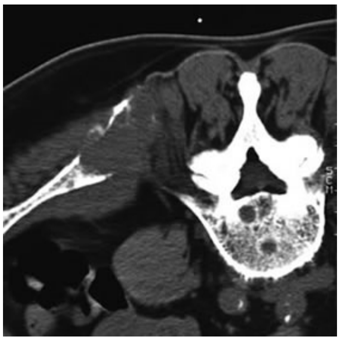
Injection of 25 ml of ethanol. Excellent pain relief.



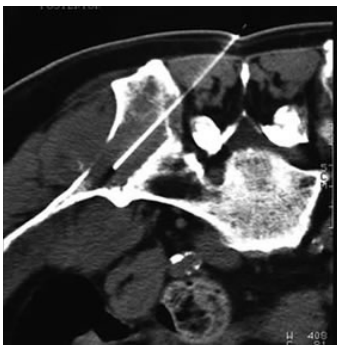
Injection of 25 ml of ethanol. Excellent pain relief.

Injection of 25 ml of ethanol. Excellent pain relief.

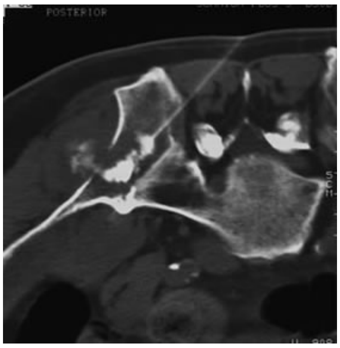
Ethanol injection is painful and alcohol instillation was performed under neuroleptanalgesia. According to the size, number of the lesions, and pain relief alcoholization is performed either as a multisession technique or as a one-shot technique.



Painful osteolytic metastases of iliac crest (breast carcinoma)



Injection of 10 ml of ethanol.



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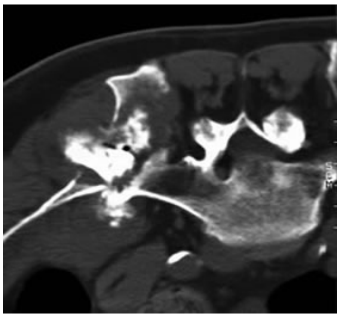

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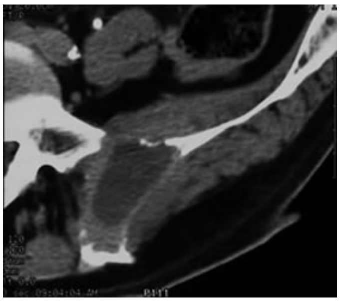


Large necrosis 10 days after the procedure.

Patient Outcome

Usually, the pain is controlled by high doses of opiate and by radiotherapy and/or chemotherapy, which have drawbacks and side effects. Reasonable pain relief with variable success rates is usually achieved but requires a two to four week delay for radiotherapy and chemotherapy to reach efficiency. One of the major advantages of the alcoholization of bone metastases is the quick pain relief occurring within 24 hours. When the pain relief was insufficient or absent the therapy was discontinued after the second alcoholization. In 74% of the cases the pain relief was satisfactory. In 26% of cases a reduction of the tumor size was observed whereas in 18,5% of cases the tumor size increased. In the remaining cases (55,5%) the tumor size remained stable. Liquefactive necrosis was found in 76% of metastases after the first ethanol instillation. Duration of pain relief ranged from 10 - 27 weeks. It should be pointed out that none of the patients survived longer than 9 months. 23% of cases, recurrence of pain happened after 2-4 months due to tumor progression. Partial densification of metastasis was observed in only 30%of cases after 6 - 8 weeks. The best results were obtained with small metastases (diameters ranging from 3-6 cm). In one patient with extension of the vertebral metastasis into the brachial plexus and severe neuralgia of C5, C6 and C7, a paraparesia was observed after instillation of alcohol in the corresponding territory. Some authors have reported fever and hyperuricemia following massive necrosis of tumor after injection of 30 ml of alcohol. In our series, low-grade fever was noticed in seven patients in the first 72 hours.

4) Cementoplasty

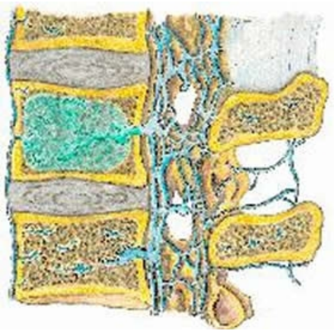
Percutaneous injection of methylmethacrylate (Cementoplasty) provides notable pain relief and bone strengthening in patients with malignant vertebral and acetabular osteolyses who are unable to tolerate surgery.

vertebroplasty diagram

Mechanism

Percutaneous injection of methylmethacrylate (Cementoplasty) allows pain reduction and bone strengthening. Owing to the mechanical properties of bone cement, which hardens as polymerization occurs, methylmethacrylate may also provide bone strengthening with stabilization of microfractures and reduction of mechanical forces. Consequently, injection of methylmethacrylate is also indicated when the object is to improve mobility in patients with osteolysis involving the weight-bearing part of the vertebral body and acetabulum (i.e., the acetabular roof). The pain-reducing effect of cement cannot be explained by consolidation of the pathologic bone alone. In fact, good pain relief is obtained after injection of only 2 ml of cement in a metastasis. Radiation therapy, which may prevent tumor growth, usually results in partial or complete pain relief, with most patients experiencing some relief within 10-14 days. Unfortunately, some patients may demonstrate insufficient pain relief or local tumor recurrence after initiation of therapy and are unable to tolerate additional therapy. Moreover, radiation therapy results in only minimal, delayed (2-4 months) bone strengthening that does not allow patients to stand who have extensive lytic lesions of the weight-bearing part of the acetabulum.

Vertebral filling



Vertebral filling

Equipment

- 10-gauge needle for thoracic and lumbar spine and 15-gauge needle for cervical spine
- Surgical hammer
- Acrylic cement (low-viscosity polymethylmethacrylate [Howmedica Simplex; Howmedica Osteonics, Rutherford, NJ, or Palacos; Schering-Plough, Kenilworth, NJ])
- Cemento ® (Optimed/Germany) to facilitate the injection of this viscous cement
- 2 - 3 g tantalum or tungsten (acrylic cement is not radio-opaque enough)
- Sterile drapes, tampons

materials for cementoplasty

materials for cementoplasty Cementoset©

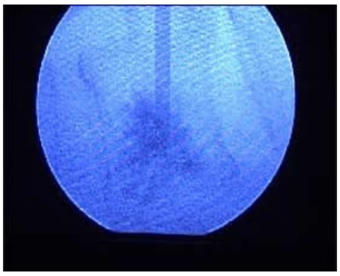
The procedure is performed under the guidance of CT and/or fluoroscopy. Injection of the cement should be controlled by real time fluoroscopy to avoid major complications. For fluoroscopy, a mobile C-arm is used, positioned in front of the CT gantry.

dual guidance

dual guidance CT and fluoroscopy

In percutaneous cementoplasty, the intervention begins with CT and is followed by fluoroscopy. The needle is placed precisely and safely under CT guidance; the injection of the acrylic cement requires real-time imaging and is therefore performed under fluoroscopic guidance.

Cement injection with Cementoset©



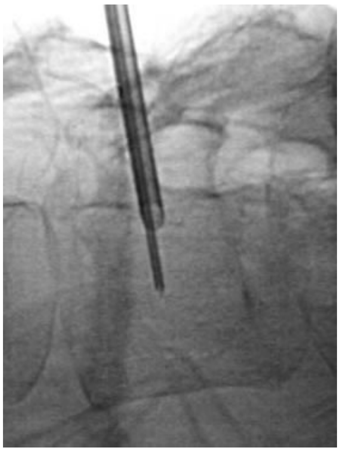
Cement injection under fluoroscopy control

Patient Selection and Technique

Injection of methylmethacrylate is usually indicated when osteolysis involves the weight-bearing part of the acetabulum (i.e., the vertebral body, the acetabular roof); in all other cases, ethanol injection is preferred. Ethanol and methylmethacrylate injections may be performed together if both weight-bearing and non-weight-bearing parts of bone are involved and extensive soft-tissue involvement is present. Moreover, these injections may be performed prior to radiation therapy, which complements their action due to similar but delayed effects on pain, or after radiation therapy that failed to relieve pain or in cases of local recurrence. Osteolytic metastases and myeloma of the vertebral body and acetabulum frequently cause severe pain and functional disability. Treatment of affected patients can be difficult. Surgery is the treatment of choice when there is no local contraindication but can be dangerous in patients with general medical impairment related to underlying disease or prior treatment. Moreover, the clinical benefits of surgical treatment must be weighed against its Undesirable effects in patients with a short life expectancy. Methylmethacrylate injection is contraindicated in:

- Coagulation disorders due to the large diameter of the needles used,
- Infection
- Lesions with epidural extension require careful injection to prevent epidural overflow and spinal cord compression by the cement.
-

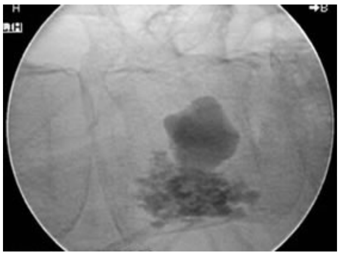
Painful metastasis of breast carcinoma. Rupture of the posterior wall



Prior to cement injection a coaxial biopsy is performed

Vertebroplasty needle placement

Vertebroplasty needle placement



Prior to cement injection a coaxial biopsy is performed followed by injection of 3.5 ml of cement under fluoroscopy control.

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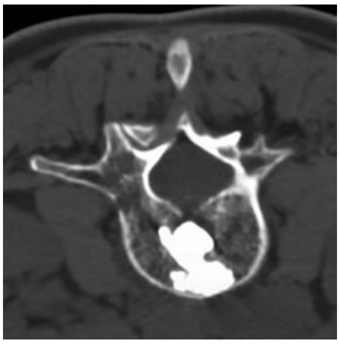
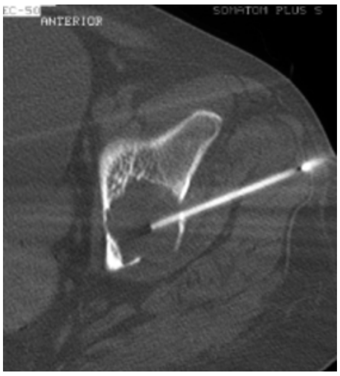
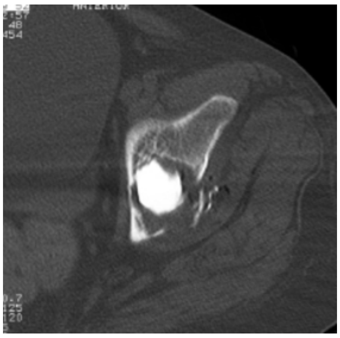


Vertebroplasty

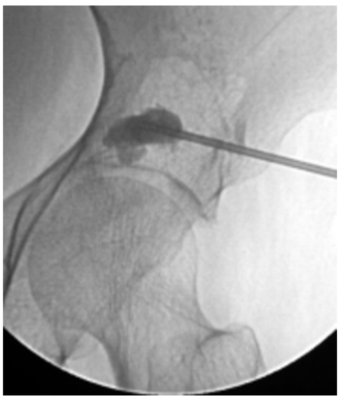
The procedure is performed under local anesthesia, usually combined with neuroleptanalgesia. After positioning the patient, a 10- to 15-gauge trocar needle is introduced into the lytic part of the tumor. Different approach routes can be selected for the vertebral body: the anterior route for the cervical level, the transpedicular and intercostovertebral routes for the thoracic level, and the posterolateral and transpedicular routes for the lumbar level. In the acetabulum, a 10-gauge needle is inserted into the osteolytic lesion via a posterior or posterolateral access route with the bevel oriented to facilitate spread of the cement in the desired direction. The needle is guided safely under CT. Cortical perforation requires the aid of a surgical hammer. When the needle is in the optimal position, the imaging mode is switched to fluoroscopy. Methylmethacrylate with the consistency of paste is then injected until resistance is met or until the cement reaches the borders of the osteolytic lesion. This phase of the procedure is guided with fluoroscopy. The patient should be under neuroleptanalgesia to control pain. A small volume (1.5-2.5 ml) of acrylic cement provides good pain relief in vertebral body tumors. In acetabular tumors, a total of 7-20 ml (mean, 12 ml) of bone cement is usually injected. Injection is immediately stopped if leakage of bone cement is detected. It is highly recommended that CT, which allows assessment of lesion filling as well as detection of methylmethacrylate leakage, is performed immediately after cement injection.



Percutaneous cementoplasty of a painful metastasis of acetabulum.



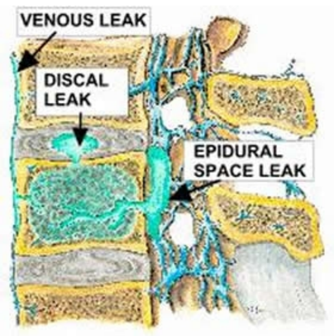
In this case 6 ml of cement was injected with excellent clinical result.



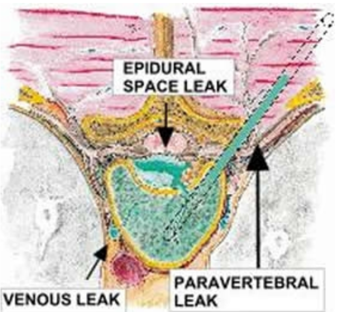
Fluoroscopy. In this case 6 ml of cement was injected with excellent clinical result.

Patient Outcome

The analgesic effect appeared within 12-48 hours after the procedure. The principal effect of percutaneous injection of methylmethacrylate or ethanol is early and frequently striking pain relief (83% of cases), especially when initial pain is considerable. Pain relief has been reported within hours to 4 days (mean, 24 hours) after methylmethacrylate injection. This pain relief is probably attributable to tumor necrosis and destruction of sensitive nerve endings in surrounding tissue by vascular, chemical, thermal, or mechanical effects. Regardless of which agent is injected, a fever and transitory worsening in pain may occur secondary to inflammatory reaction in the hours following injection. These side effects resolve spontaneously within days (mean, 1-3 days) following the procedure. Leakage of bone cement represents the principal risk associated with methylmethacrylate injection, a risk that increases when there is destruction of the cortex of the acetabular roof, rupture of the posterior wall of the vertebral body, and too fluid cement injection.



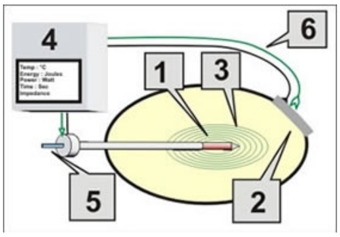
Potential complications



Potential complications

5) RADIO FREQUENCY

Radio-frequency ablation is one of the most promising thermal ablation techniques for the treatment of non-resectable tumors. The use of radio-frequency ablation was first reported in 1990 for the treatment of hepatic tumors.



RF principle

1 - needle probe

2 - dispersive electrode (ground pad)

3 - RF field

4 - RF device

5 - saline infusion

6 - closed loop

Mechanism

Alternating electric current operated in the range of radio frequency can produce a focal thermal injury in living tissue. Shielded needle electrodes are used to concentrate the energy in selected tissue. The tip of the electrode conducts the current, which causes local ionic agitation and subsequent frictional heat which leads to localized coagulation necrosis. Basically, the term radio frequency refers not to the emitted wave but rather to the alternating electric current that oscillates in the range of high frequency (200-1,200 kHz). Schematically, a closed-loop circuit is created by placing a generator, a large dispersive electrode (ground pad), a patient, and a needle electrode in series.

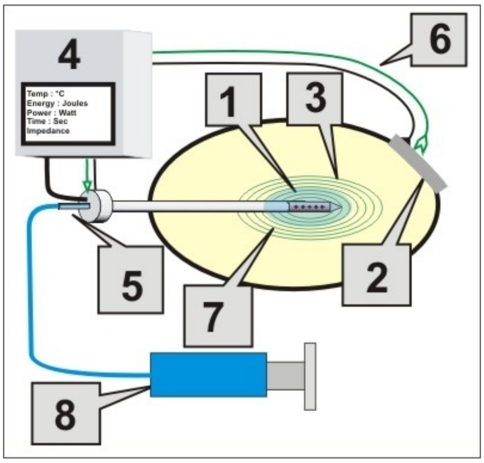


Fig 1 : principle of radio-frequency with a wet probe

1 - Needle probe

2 - dispersive electrode (ground pad)

3 - RF field

4 - RF device

5 - 7 - 8 - saline infusion

9 - closed loop

Equipment

Each radio-frequency device consists of an electrical generator, needle electrode, and ground pad. Each manufacturer has a different needle electrode design. We are using a new commercially available device using a single probe system (18- to 16-gauge) with continuous infusion of saline without exceeding a 110°C maximum temperature threshold (60W, Berchtold®/ Germany). The continuous infusion of saline at the tip of the needle allows increasing heat and electrical conductivity. The Berchtold® radio frequency device rely on an electrical measurement of tissue impedance to determine that tissue boiling is taking place. The impedance rises can be detected by the generator, which can then reduce the current output and increase the saline flow. Injection of NaCl solution during RF ablation can increase energy deposition, tissue heating, and induced coagulation.

Radio-frequency device with continuous infusion of saline.

The procedure is performed under general anesthesia in bone tumor radio-frequency ablation.

Patient Selection and Technique

Tumors should be smaller than 3 cm in diameter. Primary benign tumors like osteoid osteoma can be treated with radio-frequency ablation too. However, the small size of this tumor doesn't require large ablation with infused or cooled tip.

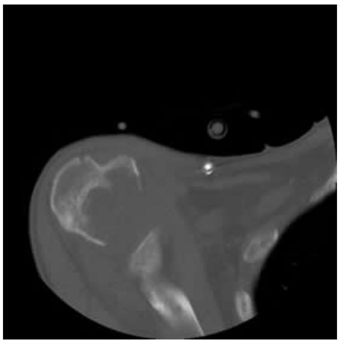
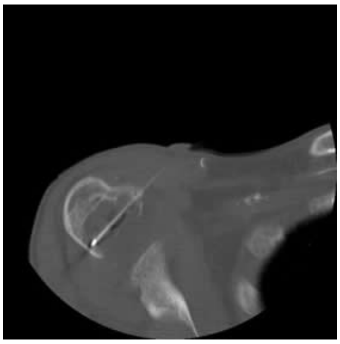


Fig 1 : Radio-frequency ablation of a painful metastases of the humerus. Alcoholization was rejected (intra-articular extension of the tumor)



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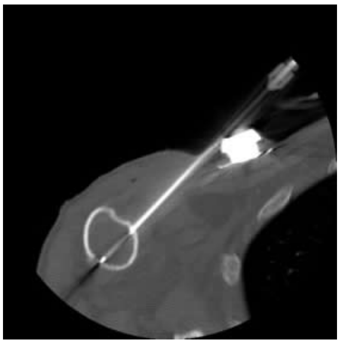
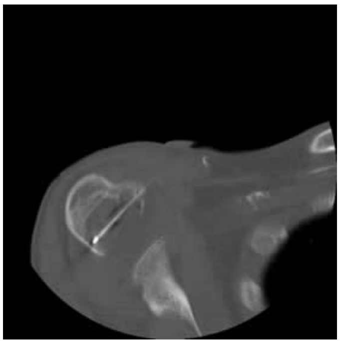


Radio-frequency ablation of a painful metastases of the humerus. Alcoholization was rejected (intra-articular extension of the tumor) Excellent pain relief after the procedure.



Radio-frequency ablation of a painful metastases of the humerus. Alcoholization was rejected (intra-articular extension of the tumor) Excellent pain relief after the procedure.

The best indications of radio frequency in bone in our opinion are:

- Painful bone metastases which can not be treated by alcohol (i.e., risk of intra-articular leak, risk of accidental neurolysis)
- Ablation of large bone metastases of thyroid cancer in association with 131 iodine therapy

- Large osteoid osteoma or osteoblastoma

Ablation strategies must vary with the size of each lesion. On the basis of a 3-cm thermal injury, tumors less than 2 cm in diameter can be treated with one or two ablations, tumors 2-3 cm require at least six overlapping ablations, and tumors greater than 3 cm require at least 12 overlapping ablations. The length of a single procedure depends on the number of ablations performed. The guidance system is chosen largely on the basis of operator preference and local experience. We are using routinely for liver and bone tumors ablations the CT guidance.

Fig 1 : Thyroid cancer with bone metastasis. Iodine 131 can not be used (too large tumor). Radio frequency ablation of the tumor with 90% of the tumor coagulated (see MR imaging). The Radio-frequency ablation was followed by iodine 131 therapy. Complete ablation of the tumor.

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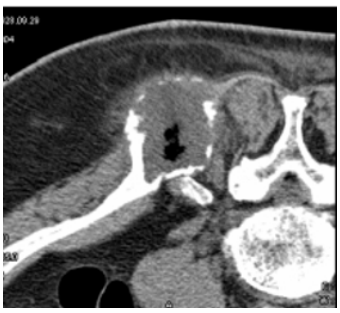

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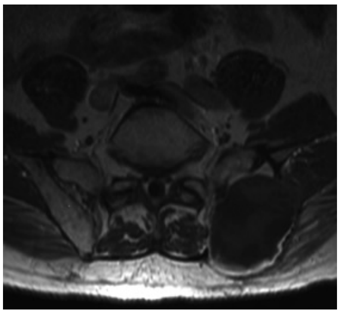

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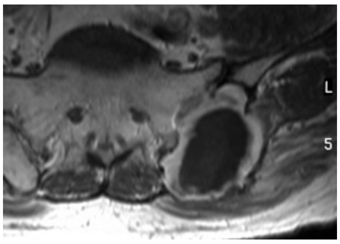

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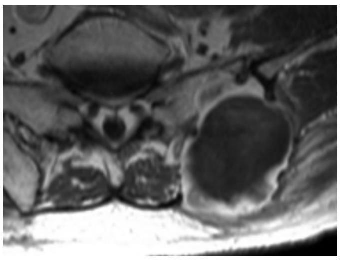


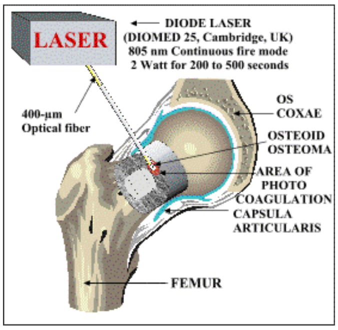
Fig 1 : MR control ,thyroid cancer with bone metastasis. Iodine 131 can not be used (too large tumor). Radio frequency ablation of the tumor with 90% of the tumor coagulated (see MR imaging). The Radio-frequency ablation was followed by Iodine 131 therapy. Complete ablation of the tumor.

Patient Outcome

MR imaging was performed 10 days after the procedure. The ablation zone appeared hypo- or non-enhancing. Complete necrosis was associated with no enhancement inside the tumor best seen on dynamic sequences. In bone metastases, the recurrences were high with 75% of incomplete resection. The best results were obtained in large metastases of thyroid cancer. As a matter of fact, the treatment has been performed in two steps. To begin the radio frequency ablation with destruction of more than 90% of the lesion followed by 131- iodine therapy to complete the ablation of residual tumor. Complete necrosis was observed in 85% of cases. Radio-frequency ablation of bone metastases was promising in pain management with 78% of satisfactory results.

6) LASER PHOTOCOAGULATION

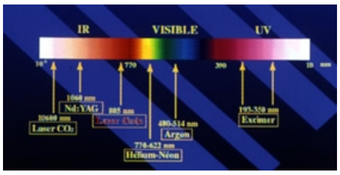
The first interstitial thermal ablation of a tumor performed with laser therapy was reported in 1983. Since then, experimental studies have shown that a reproducible thermal injury can be produced with near-infrared wavelengths lasers (neodymium yttrium aluminum garnet Nd:YAG, diode laser 800 to 1000 nanometer wavelengths). ND:YAG lasers have been used to treat tumors of the esophagus, stomach, colon, and pulmonary bronchus. The first use of lasers to treat patients with bone tumors was reported in 1993.



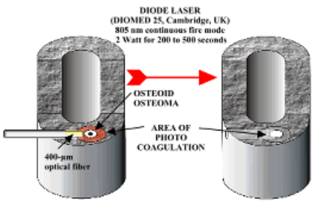
principle of laser photocoagulation

Mechanism

Lasers are intense light sources and they use photons -light energy- to produce their tissue effect. These properties enable reliable and direct transmission of high amounts of energy over long distances. Laser energy, with its powerful and precise ability to ablate, coagulate, and vaporize dense tissues as well as its transmissibility in optical fiber, is an ideal tool for use in percutaneous ablations. Interstitial laser photocoagulation (ILP) consists of percutaneous insertion of optical fibers into the tumor. The tumor is coagulated and destroyed by direct heating. From a single, bare 400-mm laser fiber, light at optical or near-infrared wavelengths will scatter within tissue and be converted into heat. Light energy of 2.0 W will produce a spherical volume of coagulative necrosis 1.6 cm in diameter in bone. Use of higher power results in charring and vaporization around the fiber tip. For producing larger volumes of necrosis (> 1.6 cm), it is necessary to fire multiple bare fibers arrayed at 1.5- to 2-cm spacing throughout a target lesion. Equipment Portable solid-state diode lasers (Diomed®) are now available with power outputs up to 60 W. This energy can be delivered through fibers over 10 m in length with the great advantage of being fully compatible with MR imaging.



Different laser wavelength



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Equipment

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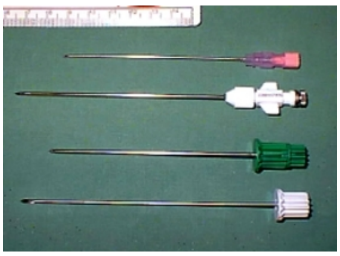


Different needles used in bone perforation.

The portable diode laser with a fiber splitter allowing simultaneous insertion of 4 fibers.

Patient Selection and Technique

The indications and contraindications for laser ablation are the same as those for radio frequency. With a low-power laser technique, a very well defined coagulation volume of predictable size and shape can be obtained in bone tissue. However, the small size of the coagulation necrosis limits its use in large tumors. The best indications are:

- Osteoid osteoma
- Contraindications of the other ablation techniques

As the nidus of the osteoid osteoma can be precisely identified on CT scanning, we have performed laser ablation under CT guidance for treatment of this tumor in our institution since June 1993. All interventions were either performed under general anesthesia or regional nerve block due to the excruciating pain during penetration of needle into the nidus. An 18-gauge spinal needle (Becton Dickinson, Rutherford, NJ) was used to access the subperiosteal nidus or cortical nidus without major ossification. For those requiring cortical perforation, a 14-gauge bone biopsy needle (Ostycut®; Angiomed/Bard, Karlsruhe/Germany) was used. In those tumors surrounded by dense cortical bone, a 14-gauge Bonopty® Penetration Set (RADI Medical Systems, Uppsala, Sweden) was used for cortical drilling. The diode laser was turned on to operate in the continuous-wave mode and to deliver power of 2W for 200 - 600 seconds (total energy, 400-1200J) depending on tumor size. From June 1993 to March 2001, CT-guided or combined CT and fluoroscopic-guided percutaneous ILP were performed on 84 patients with presumed osteoid osteomas. Majority of the nidi was located within the long bones, most common in the femur (n=32) followed by the tibia (n=14), humerus (n=8) and fibula (n=1). Ten patients had nidi situated in the spine. The rest of the tumors were located in descending order within the acetabulum (n=5), talus (n=3), calcaneum (n=3), ilium (n=2), navicular bone (n=2), coracoid process of scapula (n=1), metacarpal bone (n=1), lunate (n=1), and posterior 6th rib (n=1). Painful bone metastases were treated by inserting up to eight simultaneously energized bare fibers into the tumor with a roughly 2-cm spacing.

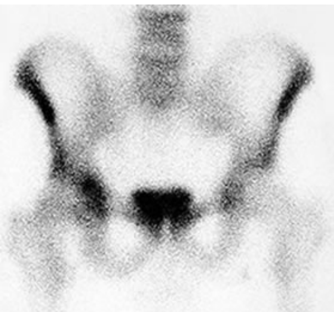


Fig 1 : intra-articular osteoid osteoma

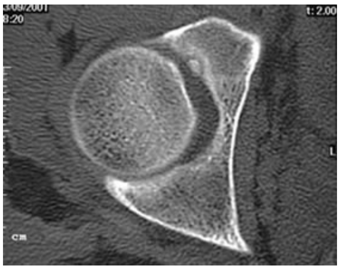
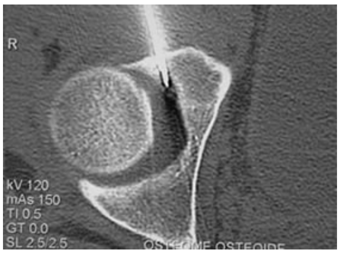
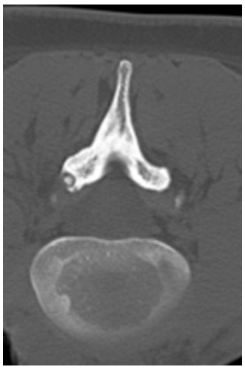


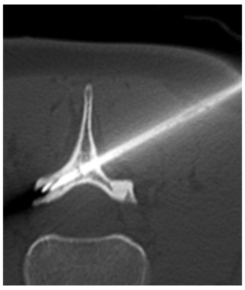
Fig 1 :an intra-articular osteoid osteoma



Percutaneous laser photocoagulation of intra-articular osteoid osteoma. A 14-gauge Ostycut needle is used. To avoid any chondrolysis of the femoral head, the articulation is filled with fluid (saline).



Spinal osteoid osteoma. The needle is inserted by intralaminar approach to avoid to fire in the direction of neurological structures.



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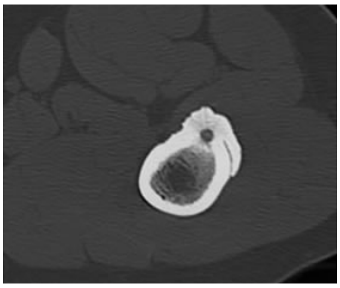
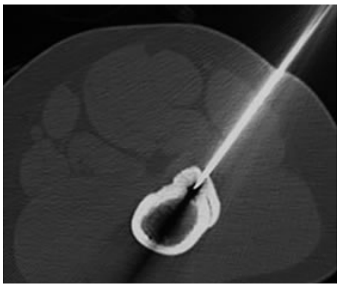


Osteoid osteoma . Drilling with the 14 gauge Bonopty needle.



Osteoid osteoma. Drilling with the 14 gauge Bonopty needle.

Laser photocoagulation of a painful osteolytic metastasis (renal cell carcinoma). First an alcoholization was programmed. The opacification shows a large vascular leak (hypervascular metastasis). The radio-frequency ablation was contraindicated due to the centro medullar nail. Laser photocoagulation with firing multiple bare fibers arrayed at 2-cm spacing throughout the lesion. Excellent pain relief.

Laser photocoagulation of a painful osteolytic metastasis (renal cell carcinoma). First an alcoholization was programmed. The opacification shows a large vascular leak (hypervascular metastasis). The radio-frequency ablation was contraindicated due to the centro medullar nail. Laser photocoagulation with firing multiple bare fibers arrayed at 2-cm spacing throughout the lesion. Excellent pain relief.

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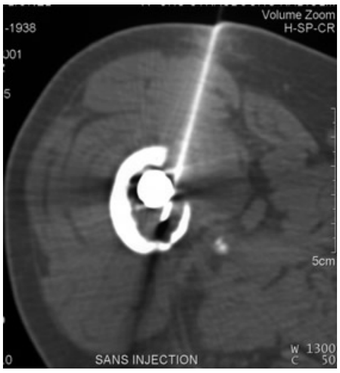

Laser photocoagulation of a painful osteolytic metastasis (renal cell carcinoma). Laser photocoagulation with firing multiple bare fibers arrayed at 2-cm spacing throughout the lesion. Excellent pain relief.

Patient Outcome

Patient Outcome In osteoid osteoma, laser photocoagulation was successful in 83 patients with pain relief observed in the majority of patients within 1 day and in almost all patients within 1 week after the procedure. In one patient, pain persisted for two months due to reflex sympathetic dystrophy. Most patients were able to return to their normal activities within 1 week. Follow-up CT examinations were performed in most of the cases and sclerosis of the nidus was generally observed after a 6-18 months period. The results were similar to radio frequency in painful bone metastasis

7) Benefits and Limitations

Percutaneous injection of methylmethacrylate (Cementoplasty) or ethanol (Alcoholization) may provide marked pain relief or bone strengthening in patients with malignant vertebral and acetabular osteolyses who are unable to tolerate surgery. Injection of methylmethacrylate is usually indicated when osteolysis involves the weight-bearing bone (i.e., vertebral body, acetabular roof). In non-weight-bearing bones, ethanol injection is preferred. Ethanol and methylmethacrylate injections may be performed together if both weight-bearing and non-weight-bearing bones are involved or extensive soft-tissue involvement is present. Moreover, these injections may be performed prior to radiation therapy, which complements their action due to similar but delayed effects on pain, or after radiation therapy that failed to relieve pain or in cases of local recurrence. The main advantage of radio-frequency ablation is the ability to create a well-controlled focal thermal injury with minimal morbidity and mortality to date. Unlike alcoholization (ethanol ablation), radio-frequency ablation creates a well-demarcated lesion. Radio frequency is particularly useful in the indication of ablation technique as a tumor therapy and, alcoholization is preferred in palliative bone metastases pain management because of its simplicity and low cost. The size of the thermal injury created by a single radio-frequency ablation is larger than that created by a single laser ablation; hence, there is less chance of missing large tumor. However, for small tumor like osteoid osteoma laser photocoagulation is an excellent alternative to other techniques. Nd:YAG or diode lasers are usually available in the majority of medium to large-sized hospitals as specialists of other disciplines also use it. With low power (typically 2W), the laser source can produce a predictable size of necrosis in proportion to the energy delivered which is much more precise than the other techniques.

The management of patients with bone tumors requires consideration of many factors:

- histology of the tumor with differentiation of benign and malignant tumors
- careful evaluation of the patient's general condition
- an understanding of the disease process
- an appreciation of the degree of bone destruction (consolidation)
- and a working knowledge of available treatment options are required.

A multidisciplinary approach is essential to determine the course of treatment that best alleviates pain, preserves function, and optimizes the quality of life remaining in the patient with malignant and metastatic disease.

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