

The American College of Radiology, with more than 30,000 members, is the principal organization of radiologists, radiation oncologists, and clinical medical physicists in the United States. The College is a nonprofit professional society whose primary purposes are to advance the science of radiology, improve radiologic services to the patient, study the socioeconomic aspects of the practice of radiology, and encourage continuing education for radiologists, radiation oncologists, medical physicists, and persons practicing in allied professional fields.

The American College of Radiology will periodically define new practice parameters and technical standards for radiologic practice to help advance the science of radiology and to improve the quality of service to patients throughout the United States. Existing practice parameters and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each practice parameter and technical standard, representing a policy statement by the College, has undergone a thorough consensus process in which it has been subjected to extensive review and approval. The practice parameters and technical standards recognize that the safe and effective use of diagnostic and therapeutic radiology requires specific training, skills, and techniques, as described in each document. Reproduction or modification of the published practice parameter and technical standard by those entities not providing these services is not authorized.

Revised 2017 (Resolution 16)*

ACR–ASNR–ASSR–SIR–SNIS PRACTICE PARAMETER FOR THE PERFORMANCE OF VERTEBRAL AUGMENTATION

PREAMBLE

This document is an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. Practice Parameters and Technical Standards are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care¹. For these reasons and those set forth below, the American College of Radiology and our collaborating medical specialty societies caution against the use of these documents in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the practitioner in light of all the circumstances presented. Thus, an approach that differs from the guidance in this document, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in this document when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document is advised to document in the patient record information sufficient to explain the approach taken.

The practice of medicine involves not only the science, but also the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to the guidance in this document will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The sole purpose of this document is to assist practitioners in achieving this objective.

¹ Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing, 831 N.W.2d 826 (Iowa 2013) Iowa Supreme Court refuses to find that the *ACR Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures* (Revised 2008) sets a national standard for who may perform fluoroscopic procedures in light of the standard's stated purpose that ACR standards are educational tools and not intended to establish a legal standard of care. See also, Stanley v. McCarver, 63 P.3d 1076 (Ariz. App. 2003) where in a concurring opinion the Court stated that "published standards or guidelines of specialty medical organizations are useful in determining the duty owed or the standard of care applicable in a given situation" even though ACR standards themselves do not establish the standard of care.

I. INTRODUCTION

This practice parameter was revised collaboratively by the American College of Radiology (ACR), the American Society of Neuroradiology (ASNR), the American Society of Spine Radiology (ASSR), the Society of Interventional Radiology (SIR), and the Society of NeuroInterventional Surgery (SNIS).

This document addresses vertebral augmentation, which includes all percutaneous techniques used to achieve internal vertebral body stabilization. Vertebral augmentation encompasses a variety of procedures for treating pathologically weakened vertebral bodies. The more common ones are vertebroplasty, which involves injecting surgical bone cement; balloon kyphoplasty, which involves inflation of a balloon in the fractured vertebral body to attempt fracture reduction before cement is injected; and/or radiofrequency ablation (RFA) and coblation techniques [1]. Other less common procedures include mechanical void creation with an osteotome, injection of bone graft material or bone substitutes, and insertion of materials and/or implants in an attempt to restore vertebral height or attempt to decrease the possibility of extravasation [2,3]. The field is evolving rapidly and this document also applies to any new methods for achieving the same end: vertebral augmentation.

A thorough review of the literature was performed. When published data were felt to be inadequate, data from the expert panel members' own quality assurance programs were used to supplement. Thresholds for quality assurance have been updated in accordance with available data in the literature.

Introduced by Galibert and Deramond et al in France in 1987 [4], vertebroplasty entails injection of material into the weakened vertebra. Radiologic imaging has been a critical part of vertebroplasty from its inception. Most procedures are performed using fluoroscopic guidance for needle placement and material injection or placement. The use of computed tomography (CT) has also been described for these purposes [5,6].

Vertebral augmentation is an established and safe procedure [4,5,7-24]. The *New England Journal of Medicine* published 2 blinded, randomized controlled trials that failed to demonstrate an advantage in their study populations for vertebroplasty over a sham intervention involving the paraspinal injection of anesthetic [25,26]. , Later blinded, randomized controlled trials (RCTs) demonstrated statistically significant benefits in pain and functional improvement following vertebroplasty compared to sham treatments [27]. Furthermore, larger non- blinded, prospective randomized controlled studies and other studies of vertebral augmentation systematic reviews and meta-analyses of the randomized controlled trials have shown its efficacy [28-48]. As with any invasive procedure, the patient is most likely to benefit when the procedure is performed in an appropriate environment by qualified physicians.

These practice parameters are intended to be used in quality improvement programs to assess vertebral augmentation procedures. The most important processes of care are (1) patient selection, (2) performing the procedure, (3) monitoring the patient and (4) appropriate patient follow-up. The outcome measures or indicators for these processes are indications, success rates, and complication rates. Outcome measures are assigned threshold levels.

Use of other technologies to treat patients for the same indications should yield similar or better success rates and complication profiles.

II. DEFINITIONS

Vertebral augmentation includes all percutaneous techniques used to achieve internal vertebral body stabilization.

Vertebroplasty is a minimally invasive surgical or interventional image-guided procedure, performed by percutaneously injecting radiopaque bone cement, osteoinductive substance, or other therapeutic material into a painful osteoporotic or neoplastic compression fracture or a painful vertebral body weakened by any other etiology.

Kyphoplasty is an image-guided procedure in which a device such as a balloon or osteotome is employed to create a cavity within the vertebra, which is then filled with material. Balloon inflation may sometimes be employed to attempt vertebral height restoration.

Other similar vertebral augmentation techniques involving the adjunctive implantation of devices in conjunction with bone filling materials have been described as well. These techniques may possibly effect vertebral height restoration and/or potentially decrease extravasation of the filler material.

Kyphoplasty is an image-guided percutaneous procedure that creates a cavity within the bone that is then filled with material.

Failure of medical therapy is defined as:

1. A patient rendered nonambulatory because of pain from a weakened or fractured vertebral body; pain persisting at a level that prevents ambulation despite 24 hours of analgesic therapy
or
2. A patient with sufficient pain from a weakened or fractured vertebral body that physical therapy is intolerable; pain persisting at that level despite 24 hours of analgesic therapy
or
3. Any patient with a weakened or fractured vertebral body and unacceptable side effects such as excessive sedation, confusion, or constipation due to the analgesic therapy necessary to reduce pain to a tolerable level

III. OVERVIEW

Vertebral compression fractures are a common and often debilitating complication of osteoporosis [49-53]. Although most fractures heal within a few weeks or months, a minority of patients continue to suffer pain that does not respond to conservative therapy [54-56]. Vertebral compression fractures are a leading cause of nursing home admission and mortality [57]. Open surgical fixation is rarely used to treat these fractures unless there is neurological compromise. The poor quality of bone at the adjacent unfractured levels does not provide a good anchor for surgical hardware, and the advanced age of most affected patients increases the morbidity and mortality risks of major surgery.

Initial success with vertebroplasty for treating aggressive hemangiomas [4,15] and osteolytic neoplasms [13,24] led to extension of the indications to include osteoporotic compression fractures refractory to medical therapy [5,7-12,14,16-22]. Vertebral augmentation is currently being used to treat a wide variety of osteolytic metastases and multiple myelomas [40,58-61].

Perioperative imaging that identifies the painful vertebral body in concordance with the clinical examination is considered essential for the safe and effective performance of vertebral augmentation.

IV. INDICATIONS AND CONTRAINDICATIONS

The major indication for vertebral augmentation is the treatment of symptomatic osteoporotic vertebral body fracture(s) refractory to medical therapy or vertebral bodies weakened because of neoplasia. Currently, there is a lack of conclusive evidence to support the use of prophylactic vertebral augmentation to prevent future osteoporotic fracture. The indications and contraindications for vertebral augmentation may change in the future as more research and information become available.

A. Indication Threshold—95%

1. Painful osteoporotic vertebral fracture(s) refractory to medical therapy
2. Vertebral bodies weakened by neoplasm
3. Symptomatic vertebral body microfracture (as documented by magnetic resonance imaging [MRI] or nuclear imaging, and/or lytic lesion seen on computed tomography [CT]) without obvious loss of vertebral body height

When fewer than 95% of vertebral augmentations in an institution are performed for the above indications, it should prompt a review of practices related to selection of patients for this procedure.

B. Absolute Contraindications

1. Septicemia
2. Active osteomyelitis of the target vertebra
3. Uncorrectable coagulopathy
4. Allergy to bone cement or opacification agent

C. Relative Contraindications

1. Radiculopathy in excess of local vertebral pain, caused by a compressive syndrome unrelated to vertebral collapse. Occasionally preoperative vertebroplasty can be performed before a spinal decompressive procedure.
2. Retropulsion of a fracture fragment causing signs and symptoms of neurological compromise
3. Epidural tumor extension with significant encroachment on the spinal canal
4. Ongoing systemic infection
5. Patient improving on medical therapy
6. Prophylaxis in osteoporotic patients (unless being performed as part of a research protocol)
7. Myelopathy or cauda equina syndrome originating at the fracture level

V. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

A. Physician

Core Privileging: This procedure is considered part of or amendable to image-guided core privileging.

Initial Qualifications

In general, the requirements for physicians performing vertebral augmentation may be met by adhering to the recommendations listed below:

1. Certification in Radiology, Diagnostic Radiology or Interventional Radiology/Diagnostic Radiology (IR/DR) by the American Board of Radiology, the American Osteopathic Board of Radiology, the Royal College of Physicians and Surgeons of Canada, or the Collège des Médecins du Québec, and has performed (with supervision) a sufficient number of vertebral augmentation procedures to demonstrate competency as attested by the supervising physician(s).
or
2. Completion of an approved residency or fellowship program by the Accreditation Council for Graduate Medical Education (ACGME), the Royal College of Physicians and Surgeons of Canada (RCPSC), the Collège des Médecins du Québec, or an American Osteopathic Association (AOA) approved residency program and has performed (with supervision) a sufficient number of vertebral augmentation procedures to demonstrate competency as attested by the supervising physician(s).
or
3. A physician who did not successfully complete an ACGME approved radiology residency or fellowship program that included the above may still be considered qualified to perform vertebral augmentation provided the following can be demonstrated: the physician must have at least 1 year of experience in performing percutaneous image-guided spine procedures, during which the physician was supervised by a physician with active privileges in these spine procedures. During this year he or she must have performed a minimum of 5 vertebral augmentations as primary operator with outcomes within the quality improvement thresholds of this practice parameter.
and
4. Physicians meeting any of the qualifications in 1, 2, or 3 above must have written substantiation that

they are familiar with all of the following:

- a. Indications and contraindications for vertebral augmentation.
- b. Periprocedural and intraprocedural assessment, monitoring, and management of the patient, and particularly the recognition and initial management of procedural complications.
- c. Appropriate use and operation of fluoroscopic and radiographic equipment, digital subtraction systems, and other electronic imaging systems.
- d. Principles of radiation protection, hazards of radiation, and radiation monitoring requirements as they apply to both patients and personnel.
- e. Anatomy, physiology, and pathophysiology of the spine, spinal cord, and nerve roots.
- f. Pharmacology of contrast agents and implanted materials and recognition and treatment of potential adverse reactions to these substances.
- g. Technical aspects of performing this procedure.

The written substantiation should come from the chief of interventional radiology, the chief of neuroradiology, the chief of interventional neuroradiology, or the chair of the department of the institution in which the physician will be providing these services². Substantiation could also come from a prior institution in which the physician provided the services, but only at the discretion of the current interventional, neurointerventional, or neuroradiology chief, or the chair who solicits the additional input.

and

5. Physicians must possess certain fundamental knowledge and skills that are required for the appropriate application and safe performance of vertebral augmentation:
 - a. In addition to a basic understanding of spinal anatomy, physiology, and pathophysiology, the physician must have sufficient knowledge of the clinical and imaging evaluation of patients with spinal disorders to determine those for whom vertebral augmentation is indicated.
 - b. The physician must fully appreciate the benefits and risks of vertebral augmentation and the alternatives to the procedure.
 - c. The physician is required to be competent in the use of fluoroscopy, CT, and MRI or interpretation of images in the modalities used to evaluate potential patients and guide the vertebral augmentation procedure.
 - d. The physician should be able to recognize, interpret, and act immediately on image findings.
 - e. The physician must have the ability, skills, and knowledge to evaluate the patient's clinical status and to identify those patients who might be at increased risk, who may require additional perioperative care, or who have relative contraindications to the procedure.
 - f. The physician must be capable of providing the initial clinical management of complications of vertebral augmentation, including administration of basic life support, treatment of pneumothorax, and recognition of spinal cord compression.
 - g. Training in radiation physics and safety is an important component of these requirements. Such training is important to maximize both patient and physician safety. It is highly recommended that the physician have adequate training in and be familiar with the principles of radiation exposure, the hazards of radiation exposure to both patients and radiologic personnel, and the radiation monitoring requirements for the imaging methods listed above.

Some methods of vertebral augmentation may require specialized training and experience, and such needs should be assessed before a physician contemplates using any method.

Maintenance of Competence

Physicians must perform a sufficient number of overall procedures applicable to the spectrum of core privileges to maintain their skills, with acceptable success and complication rates as laid out in this parameter. Continued competence should depend on participation in a quality improvement program that monitors these rates. Consideration should be given to the physician's lifetime practice experience.

² At institutions in which there is joint (dual) credentialing across departments doing like procedures, this substantiation of experience should be done by the chairs of both departments to ensure equity of experience among practitioners when their training backgrounds differ [43].

Continuing Medical Education

The physician's continuing education should be in accordance with the [ACR Practice Parameter for Continuing Medical Education \(CME\)](#) [62].

B. Nonphysician Practitioners

Physician assistants and nurse practitioners can be valuable members of the interventional radiology team but not as primary operator. These nonphysician practitioners can function as independent members of the team but not as primary operator. See the [ACR–SIR–SNIS–SPR Practice Parameter for Interventional Clinical Practice and Management](#) [63].

C. Qualified Medical Physicist

A Qualified Medical Physicist is an individual who is competent to practice independently one or more of the subfields in medical physics. The American College of Radiology (ACR) considers certification, continuing education, and experience in the appropriate subfield(s) to demonstrate that an individual is competent to practice one or more of the subfields in medical physics and to be a Qualified Medical Physicist. The ACR strongly recommends that the individual be certified in the appropriate subfield(s) by the American Board of Radiology (ABR), the Canadian College of Physics in Medicine, or the American Board of Medical Physics (ABMP).

A Qualified Medical Physicist should meet the [ACR Practice Parameter for Continuing Medical Education \(CME\)](#). (ACR Resolution 17, 1996 – revised in 2012, Resolution 42) [62]

The appropriate subfield in medical physics for this practice parameter is Diagnostic Medical Physics. (Previous medical physics certification categories including Radiological Physics, Diagnostic Radiological Physics, and Diagnostic Imaging Physics are also acceptable.)

D. Registered Radiologist Assistant

A registered radiologist assistant is an advanced level radiographer who is certified and registered as a radiologist assistant by the American Registry of Radiologic Technologists (ARRT) after having successfully completed an advanced academic program encompassing an ACR/ASRT (American Society of Radiologic Technologists) radiologist assistant curriculum and a radiologist-directed clinical preceptorship. Under radiologist supervision, the radiologist assistant may perform patient assessment, patient management and selected examinations as delineated in the Joint Policy Statement of the ACR and the ASRT titled “Radiologist Assistant: Roles and Responsibilities” and as allowed by state law. The radiologist assistant transmits to the supervising radiologists those observations that have a bearing on diagnosis. Performance of diagnostic interpretations remains outside the scope of practice of the radiologist assistant. (ACR Resolution 34, adopted in 2006)

E. Radiologic Technologist

The technologist, together with the physician and the nursing personnel, should be responsible for patient comfort. The technologist should be able to prepare and position the patient for the vertebral augmentation procedure and, together with the nurse, monitor the patient during the procedure. The technologist should obtain the imaging data in a manner prescribed by the supervising physician. The technologist should also perform regular quality control testing of the equipment under the supervision of the Qualified Medical Physicist.

The technologist should have appropriate training and experience in the vertebral augmentation procedure and be certified by the American Registry of Radiologic Technologists (ARRT) and/or have an unrestricted state license.

F. Nursing Services

Nursing services are an integral part of the team for perioperative patient management and education and may assist the physician in monitoring the patient during the vertebral augmentation procedure.

VI. SPECIFICATIONS OF THE PROCEDURE

A. Technical Requirements

Vertebral augmentation may be performed with either fluoroscopy or CT imaging guidance. The choice is a matter of operator preference and patient characteristics. In either case, there are several technical requirements to ensure safe and successful vertebral augmentations. These include adequate institutional facilities, imaging and monitoring equipment, and support personnel. The following are minimum requirements for any institution in which vertebral augmentation is to be performed:

1. A procedural suite large enough to allow safe and straightforward transfer of the patient from bed to procedural table with sufficient space for appropriate positioning of patient monitoring equipment, anesthesia equipment, respirators, etc. There should be adequate space for the operating team to work unencumbered on either side of the patient and for the circulation of other staff within the room without contaminating the sterile conditions.
2. The majority of these procedures are performed under fluoroscopic guidance. A high-resolution image intensifier or flat-panel detector and video system with adequate shielding, capable of rapid imaging in orthogonal planes and with capabilities for permanent image recording, is strongly recommended. The fluoroscope should be compliant with IEC 601-2-43 [64]. Imaging findings are acquired and stored either on conventional film or digitally on computerized storage media. Imaging and image recording must be consistent with the as low as reasonably achievable (ALARA) radiation safety guidelines.
3. Prompt access to CT and MRI is necessary to evaluate potential complications. This may be particularly important if vertebral augmentation is planned in patients with osteolytic vertebral metastasis and/or with significant pre-existing spinal canal compromise.
4. The facility must provide adequate resources for observing patients during and after vertebral augmentation. Physiologic monitoring devices appropriate to the patient's needs—including blood pressure monitoring, pulse oximetry, and electrocardiography—and equipment for cardiopulmonary resuscitation must be available in the procedural suite.

B. Surgical and Emergency Support

Although serious complications of vertebral augmentation are infrequent, there should be prompt access to surgical, interventional, and medical management of complications.

C. Patient Care

1. Preprocedural care
 - a. The clinical history and findings, including the indications for the procedure, must be reviewed and recorded in the patient's medical record by the physician performing the procedure. Specific inquiry should be made with respect to relevant medications, prior allergic reactions, and bleeding/clotting status.
 - b. The vital signs and the results of physical and neurological examinations must be obtained and recorded.
 - c. The indication(s) for the procedure, including (if applicable) documentation of failed medical therapy, must be recorded.
 - d. The indication(s) for treatment of the fracture should have documentation of imaging correlation and confirmation.
2. Procedural care

- a. Adherence to the Joint Commission’s current Universal Protocol for Preventing Wrong Site, Wrong Procedure, Wrong Person Surgery™ is required for procedures in non–operating room settings, including bedside procedures.
The organization should have processes and systems in place for reconciling differences in staff responses during the “time-out.”
 - b. Vital signs should be obtained at regular intervals during the course of the procedure, and a record of these measurements should be maintained.
 - c. Patients undergoing vertebral augmentation must have intravenous access in place for the administration of fluids and medications as needed.
 - d. If the patient receives sedation, pulse oximetry must be used. Administration of sedation for vertebral augmentation should be in accordance with the [ACR–SIR Practice Parameter for Sedation/Analgesia](#) [65]. A registered nurse or other appropriately trained personnel should be present and have primary responsibility for monitoring the patient. A record of medication doses and times of administration should be maintained.
3. Postprocedural care
- a. A procedural note should be written in the patient’s medical record summarizing the course of the procedure and what was accomplished, any immediate complications, and the patient’s status at the conclusion of the procedure (see section VIII.A.2 below). This note may be brief if the formal report will be available within a few hours. This information should be communicated to the referring physician in a timely manner. A more detailed summary of the procedure should be written in the medical record if the formal transcribed report will not be on the medical record within the same day.
 - b. All patients should be at bed rest and observed during the initial postprocedural period. The length of this period will depend on the patient’s medical condition.
 - c. During the immediate postprocedural period, skilled nurses or other appropriately trained personnel should monitor the patient’s vital signs, urinary output, sensorium, and motor strength. Neurological status should be assessed frequently at regular intervals. Initial ambulation of the patient must be carefully supervised.
 - d. The operating physician or a qualified designee (another physician or a nurse) should evaluate the patient after the initial postprocedural period, and these findings should be summarized in a progress note on the patient’s medical record. The physician or designee must be available for continuing postprocedural care at the facility and after discharge.

VII. EQUIPMENT QUALITY CONTROL

Each facility should have documented policies and procedures for monitoring and evaluating the effective management, safety, and proper performance of imaging and interventional equipment. The quality control program should be designed to maximize the quality of the diagnostic information. This may be accomplished as part of a routine preventive maintenance program.

VIII. QUALITY IMPROVEMENT AND DOCUMENTATION

A. Documentation

Results of vertebral augmentation procedures should be monitored on a continuous basis. Records should be kept of both immediate and long-term results and complications. The number of complications should be documented. Any biopsies performed in conjunction with vertebral augmentation should be followed up to detect and record any false negative and false positive results.

A permanent record of vertebral augmentation procedures should be maintained in a retrievable image storage format.

1. Imaging labeling should include permanent identification containing:

- a. Facility name and location
 - b. Examination date
 - c. Patient's first and last names
 - d. Patient's identification number and/or date of birth.
2. The initial progress note and final report should include:
- a. Procedure undertaken and its purpose
 - b. Type of anesthesia used (local, moderate, deep, or general)
 - c. Listing of level(s) treated and amount of cement injected at each level
 - d. Evaluation of injection site and focused neurologic examination
 - e. Immediate complications, if any, including treatment and outcome
 - f. Radiation dose estimate (or fluoroscopy time and the number of images obtained on equipment that does not provide direct dosimetry information) [66-68]
3. Follow-up documentation:
- a. Postprocedure evaluation to assess patient response (pain relief, mobility improvement). Standardized assessment tools such as the SF 36 and the Roland-Morris disability scale may be useful for both preoperative and postoperative patient evaluation
 - b. Evaluation of injection site and focused neurologic examination
 - c. Delayed complications, if any, including treatment and outcome
 - d. Pathology (biopsy) results, if any
 - e. Record of communications with patient and referring physician
 - f. Patient disposition

Reporting should be in accordance with the [ACR–SIR–SPR Practice Parameter for the Reporting and Archiving of Interventional Radiology Procedures](#) [69].

B. Informed Consent and Procedural Risk

Informed consent or emergency administrative consent must be obtained and must comply with the [ACR–SIR Practice Parameter on Informed Consent for Image-Guided Procedures](#) [70]. Risks cited may include, but are not limited to, infection, bleeding, allergic reaction, rib or vertebral fracture, vessel injury, pneumothorax (for appropriate levels), implanted material displacement, worsening pain or paralysis, spinal cord or nerve injury, pulmonary complication, or death. The potential need for immediate surgical intervention should be discussed. The possibility that the patient may not experience significant pain relief should also be discussed.

C. Success and Complication Rates and Thresholds [4,5,7-24]

Although practicing physicians should strive to achieve perfect outcomes (ie, 100% success, 0% complications), in practice, all physicians will fall short of this ideal to a variable extent. Therefore, indicator thresholds may be used to assess the efficacy of ongoing quality improvement programs. For the purposes of these practice parameters, a threshold is a specific level of an indicator that should prompt a review. Procedure thresholds or overall thresholds refer to a group of indicators for a procedure, for example, major complications. Individual complications may also be associated with complication-specific thresholds. When measures such as indications or success rates fall below a minimum threshold or when complication rates exceed a maximum threshold, a review should be performed to determine causes and to implement changes if necessary. For example, if the incidence of fracture of rib or other bone is one measure of the quality of vertebral augmentation, values in excess of the defined threshold (in this case <1%) should trigger a review of policies and procedures within the department to determine the causes and to implement changes to lower the incidence of the complication.

Thresholds may vary from those listed herein; for example, patient referral patterns and selection factors may dictate a different threshold value for a particular indicator at a particular institution. Therefore, setting universal thresholds is very difficult, and each department is urged to alter the thresholds as needed to higher or lower values to meet its own quality improvement program needs.

Complications can be stratified on the basis of outcome. Major complications result in admission to a hospital for therapy (for outpatient procedures), an unplanned increase in the level of care, prolonged hospitalization, permanent adverse sequelae, or death. Minor complications result in no sequelae but may require nominal therapy or a short hospital stay for observation (generally overnight; see Appendix A). The complication rates and thresholds described herein refer to major complications.

Routine periodic review of all cases having less than perfect outcomes is strongly encouraged. Serious complications of vertebral augmentation are infrequent. A review is therefore recommended for all instances of death, infection, or symptomatic pulmonary embolus.

Success Rates

When vertebral augmentation is performed, success is defined as achievement of significant pain relief, reduced disability, and/or improved quality of life. These should be measured by at least 1 of the relevant and validated measurement tools, such as the 10-point numerical pain rating scale score or a visual analogue scale score (Roland-Morris Back Pain score, Oswestry Disability Index, The Short Form (36) Health Survey, or similar outcome tool to measure pain, disability, and/or quality of life).

When vertebral augmentation is performed for neoplastic involvement, success is defined as achievement of significant pain relief and/or improved mobility as measured by validated measurement tools.

Table 1 Vertebral Augmentation Success Rates [72-80]

	Published Success Rates	Threshold for Review
Neoplastic, all causes	70% to 92%	<60%
Osteoporosis, all causes	80% to 98%	<70%

Complications

Major complications occur in less than 1% of patients treated for compression fractures secondary to osteoporosis and in less than 5% of treated patients with neoplastic involvement. Published complication rates and suggested thresholds are given below.

Published rates for individual types of complications are highly dependent on patient selection and are based on series comprising several hundred patients, which is a volume larger than most individual practitioners are likely to treat. It is also recognized that a single complication can cause a rate to cross above a complication-specific threshold when the complication occurs in a small volume of patients, for example, early in a quality improvement program. In this situation, the suggested threshold is more appropriate for use in a quality improvement program than is the published rate.

Table 2 Specific Complications for Vertebral Augmentation [73,74,81-86]

Specific Complication	Published Rates	Thresholds for Review
Transient neurological deficit (within 30 days of the procedure)		
Osteoporosis	1%	>2%
Neoplasm	10%	>10%
Permanent neurological deficit (within 30 days of the procedure or requiring surgery)		
Osteoporosis	<1%	>1%
Neoplasm	2%	>5%
Fracture of rib, sternum, or vertebra	1%	>2%
Allergic or idiosyncratic reaction	<1%	>1%

Specific Complication	Published Rates	Thresholds for Review
Infection	<1%	>0%
Symptomatic pulmonary material embolus	<1%	>0%
Significant hemorrhage or vascular injury	<1%	>0%
Symptomatic hemothorax or pneumothorax	<1%	>0%
Death	<1%	>0%

The overall procedure threshold for all complications resulting from vertebral augmentation performed for osteoporosis is 2%, and when performed for neoplastic indications it is 10%.

IX. RADIATION SAFETY IN IMAGING

Radiologists, medical physicists, registered radiologist assistants, radiologic technologists, and all supervising physicians have a responsibility for safety in the workplace by keeping radiation exposure to staff, and to society as a whole, “as low as reasonably achievable” (ALARA) and to assure that radiation doses to individual patients are appropriate, taking into account the possible risk from radiation exposure and the diagnostic image quality necessary to achieve the clinical objective. All personnel that work with ionizing radiation must understand the key principles of occupational and public radiation protection (justification, optimization of protection and application of dose limits) and the principles of proper management of radiation dose to patients (justification, optimization and the use of dose reference levels) http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1578_web-57265295.pdf

Nationally developed guidelines, such as the ACR’s [Appropriateness Criteria](#)[®], should be used to help choose the most appropriate imaging procedures to prevent unwarranted radiation exposure.

Facilities should have and adhere to policies and procedures that require varying ionizing radiation examination protocols (plain radiography, fluoroscopy, interventional radiology, CT) to take into account patient body habitus (such as patient dimensions, weight, or body mass index) to optimize the relationship between minimal radiation dose and adequate image quality. Automated dose reduction technologies available on imaging equipment should be used whenever appropriate. If such technology is not available, appropriate manual techniques should be used.

Additional information regarding patient radiation safety in imaging is available at the Image Gently[®] for children (www.imagegently.org) and Image Wisely[®] for adults (www.imagewisely.org) websites. These advocacy and awareness campaigns provide free educational materials for all stakeholders involved in imaging (patients, technologists, referring providers, medical physicists, and radiologists).

Radiation exposures or other dose indices should be measured and patient radiation dose estimated for representative examinations and types of patients by a Qualified Medical Physicist in accordance with the applicable ACR Technical Standards. Regular auditing of patient dose indices should be performed by comparing the facility’s dose information with national benchmarks, such as the ACR Dose Index Registry, the NCRP Report No. 172, Reference Levels and Achievable Doses in Medical and Dental Imaging: Recommendations for the United States or the Conference of Radiation Control Program Director’s National Evaluation of X-ray Trends. (ACR Resolution 17 adopted in 2006 – revised in 2009, 2013, Resolution 52).

X. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION

Policies and procedures related to quality, patient education, infection control, and safety should be developed and implemented in accordance with the ACR Policy on Quality Control and Improvement, Safety, Infection Control, and Patient Education appearing under the heading *Position Statement on QC & Improvement, Safety, Infection Control, and Patient Education* on the ACR website (<http://www.acr.org/guidelines>).

ACKNOWLEDGEMENTS

This practice parameter was revised according to the process described under the heading *The Process for Developing ACR Practice Parameters and Technical Standards* on the ACR website (<http://www.acr.org/guidelines>) by the Committee on Practice Parameters – Interventional and Cardiovascular Radiology of the ACR Commission on Interventional and Cardiovascular Radiology and the Committee on Practice Parameters – Neuroradiology of the ACR Commission on Neuroradiology, in collaboration with the ASNR, the ASSR, the SIR, and the SNIS.

Collaborative Committee – members represent their societies in the initial and final revision of this practice parameter

ACR

Joshua A. Hirsch, MD, FACR, FSIR, Chair

Allan L. Brook, MD

Ronil V. Chandra, MBBS, FRANZCR

A. Orlando Ortiz, MD, MBA, FACR

ASNR

Raymond K. Tu, MD, FACR

ASSR

John D. Barr, MD, FACR, FSIR

SIR

Sandeep Bagla, MD

Drew M. Caplin, MD

J. Kevin McGraw, MD

Joan C. Wojak, MD, FACR

SNIS

Richard P. Klucznik, MD, FACR

Philip M. Meyers, MD, FA CR

Committee on Practice Parameters – Interventional and Cardiovascular Radiology

(ACR Committee responsible for sponsoring the draft through the process)

Clayton K. Trimmer, DO, FACR, FAOCR, FSIR, Chair

Chaitanya Ahuja, MBBS

Drew M. Caplin, MD

Sean R. Dariushnia, MD

Jeremy L. Friese, MD, MBA

Joshua A. Hirsch, MD, FACR, FSIR

Kelvin Hong, MD, FSIR

Elizabeth A. Ignacio, MD, FSIR

Sanjeeva P. Kalva, MD, FSIR

Minhajuddin S. Khaja, MD, MBA

Margaret Hsin-Shung Lee, MD

Susan K. O'Horo, MD, FSIR

John D. Prologo, MD

Stephen P. Reis, MD

Wael Saad, MD, FSIR

Beth A. Schueler, PhD, FACR, FAAPM

Sanjit Tewari, MD

Joan C. Wojak, MD, FACR, FSIR

Committee on Practice Parameters – Neuroradiology

(ACR Committee responsible for sponsoring the draft through the process)

John E. Jordan, MD, MPP, FACR, Chair

Merita A. Bania, MD

Kristine A. Blackham, MD

Brian A. Conley, MD

H. Simms Hardin, IV, MD

Steven W. Hetts, MD

Jacqueline C. Junn, MD

Stephen A. Kieffer, MD, FACR

Robert McDonald, MD

Alexander M. McKinney, IV, MD

David M. Mirsky, MD

Robin J. Mitnick, MD

A. Orlando Ortiz, MD, MBA, FACR

Robert J. Rapoport, MD, FACR

Glenn H. Roberson, MD

Rathan M. Subramaniam, MD, PhD, MPH

Raymond K. Tu, MD, FACR

Max Wintermark, MD

Philip S. Cook, MD, FACR, FSIR, Chair, Commission on Interventional and Cardiovascular Radiology

Alexander M. Norbash, MD, FACR, Chair, Commission on Neuroradiology

Jacqueline A. Bello, MD, FACR, Chair, Commission on Quality and Safety

Matthew S. Pollack, MD, FACR, Chair, Committee on Practice Parameters and Technical Standards

Comments Reconciliation Committee

I. Raymond Kirk, III, MD, FACR, Chair
Gregory N. Nicola, MD, Co-Chair
Sandeep Bagla, MD
John D. Barr, MD, FACR, FSIR
Jacqueline A. Bello, MD, FACR
Allan L. Brook, MD
Drew M. Caplin, MD
Ronil V. Chandra, MBBS, FRANZCR
Philip S. Cook, MD, FACR, FSIR
William T. Herrington, MD, FACR
Joshua A. Hirsch, MD, FACR, FSIR
John E. Jordan, MD, MPP, FACR

Richard P. Klucznik, MD, FACR
J. Kevin McGraw, MD
Philip M. Meyers, MD, FACR
Alexander M. Norbash, MD, FACR
A. Orlando Ortiz, MD, MBA, FACR
Matthew S. Pollack, MD, FACR
Jeffrey A. Stone, MD, FACR
Timothy L. Swan, MD, FACR, FSIR
Clayton K. Trimmer, DO, FACR, FAOCR, FSIR
Raymond K. Tu, MD, FACR
Joan C. Wojak, MD, FACR

REFERENCES

1. Manchikanti L, Pampati V, Hirsch JA. Analysis of utilization patterns of vertebroplasty and kyphoplasty in the Medicare population. *Journal of neurointerventional surgery*. 2013;5(5):467-472.
2. Barr JD, Jensen ME, Hirsch JA, et al. Position statement on percutaneous vertebral augmentation: a consensus statement developed by the Society of Interventional Radiology (SIR), American Association of Neurological Surgeons (AANS) and the Congress of Neurological Surgeons (CNS), American College of Radiology (ACR), American Society of Neuroradiology (ASNR), American Society of Spine Radiology (ASSR), Canadian Interventional Radiology Association (CIRA), and the Society of NeuroInterventional Surgery (SNIS). *J Vasc Interv Radiol*. 2014;25(2):171-181.
3. Chandra RV, Meyers PM, Hirsch JA, et al. Vertebral augmentation: report of the Standards and Guidelines Committee of the Society of NeuroInterventional Surgery. *Journal of neurointerventional surgery*. 2014;6(1):7-15.
4. Galibert P, Deramond H, Rosat P, Le Gars D. [Preliminary note on the treatment of vertebral angioma by percutaneous acrylic vertebroplasty]. *Neurochirurgie*. 1987;33(2):166-168.
5. Gangi A, Kastler BA, Dietemann JL. Percutaneous vertebroplasty guided by a combination of CT and fluoroscopy. *AJNR Am J Neuroradiol*. 1994;15(1):83-86.
6. Jensen ME, McGraw JK, Cardella JF, Hirsch JA. Position statement on percutaneous vertebral augmentation: a consensus statement developed by the American Society of Interventional and Therapeutic Neuroradiology, Society of Interventional Radiology, American Association of Neurological Surgeons/Congress of Neurological Surgeons, and American Society of Spine Radiology. *J Vasc Interv Radiol*. 2009;20(7 Suppl):S326-331.
7. Barr JD, Barr MS, Lemley TJ, McCann RM. Percutaneous vertebroplasty for pain relief and spinal stabilization. *Spine*. 2000;25(8):923-928.
8. Barr MS, Barr JD. Invited commentary. Percutaneous vertebroplasty: state of the art. *Radiographics*. 1998;18:320-322.
9. Cardon T, Hachulla E, Flipo RM, et al. Percutaneous vertebroplasty with acrylic cement in the treatment of a Langerhans cell vertebral histiocytosis. *Clin Rheumatol*. 1994;13(3):518-521.
10. Chiras J, Deramond H. Complications des vertebroplasties. In: Saillant G, Laville C, ed. *Echecs et complications de la chirurgie du rachis: chirurgie de reprise*. Paris, France: Sauramps Medical; 1995:149-153.
11. Chiras J, Depriester C, Weill A, Sola-Martinez MT, Deramond H. [Percutaneous vertebral surgery. Technics and indications]. *J Neuroradiol*. 1997;24(1):45-59.
12. Cotten A, Boutry N, Cortet B, et al. Percutaneous vertebroplasty: state of the art. *Radiographics*. 1998;18(2):311-320; discussion 320-313.

13. Cotten A, Dewatre F, Cortet B, et al. Percutaneous vertebroplasty for osteolytic metastases and myeloma: effects of the percentage of lesion filling and the leakage of methyl methacrylate at clinical follow-up. *Radiology*. 1996;200(2):525-530.
14. Debussche-Depriester C, Deramond H, Fardellone P, et al. Percutaneous vertebroplasty with acrylic cement in the treatment of osteoporotic vertebral crush fracture syndrome. *Neuroradiology*. 1991;33:S149-S152.
15. Deramond H, Darrason R, Galibert P. Percutaneous vertebroplasty with acrylic cement in the treatment of aggressive spinal angiomas. *Rachis*. 1989;1:143-153.
16. Deramond H, Galibert P, Debussche-Depriester C. Vertebroplasty. *Neuroradiology*. 1991;33:S177-S178.
17. Deramond H, Depriester C, Toussaint P, Galibert P. Percutaneous Vertebroplasty. *Semin Musculoskelet Radiol*. 1997;1(2):285-296.
18. Do HM, Jensen ME, Marx WF, Kallmes DF. Percutaneous vertebroplasty in vertebral osteonecrosis (Kummell's spondylitis). *Neurosurg Focus*. 1999;7(1):e2.
19. Dousset V, Mousselard H, de Monck d'User L, et al. Asymptomatic cervical haemangioma treated by percutaneous vertebroplasty. *Neuroradiology*. 1996;38(4):392-394.
20. Jensen ME, Evans AJ, Mathis JM, Kallmes DF, Cloft HJ, Dion JE. Percutaneous polymethylmethacrylate vertebroplasty in the treatment of osteoporotic vertebral body compression fractures: technical aspects. *AJNR Am J Neuroradiol*. 1997;18(10):1897-1904.
21. Lemley TJ, Barr MS, Barr JD, et al. Percutaneous vertebroplasty: a new technique for treatment of benign and malignant vertebral body compression fractures. *Surgical Physician Assistant*. 1997;3:24-27.
22. Mathis JM, Petri M, Naff N. Percutaneous vertebroplasty treatment of steroid-induced osteoporotic compression fractures. *Arthritis Rheum*. 1998;41(1):171-175.
23. Padovani B, Kasriel O, Brunner P, Peretti-Viton P. Pulmonary embolism caused by acrylic cement: a rare complication of percutaneous vertebroplasty. *AJNR Am J Neuroradiol*. 1999;20(3):375-377.
24. Weill A, Chiras J, Simon JM, Rose M, Sola-Martinez T, Enkaoua E. Spinal metastases: indications for and results of percutaneous injection of acrylic surgical cement. *Radiology*. 1996;199(1):241-247.
25. Buchbinder R, Osborne RH, Ebeling PR, et al. A randomized trial of vertebroplasty for painful osteoporotic vertebral fractures. *N Engl J Med*. 2009;361(6):557-568.
26. Kallmes DF, Comstock BA, Heagerty PJ, et al. A randomized trial of vertebroplasty for osteoporotic spinal fractures. *N Engl J Med*. 2009;361(6):569-579.
27. Clark W, Bird P, Gonski P, et al. Safety and efficacy of vertebroplasty for acute painful osteoporotic fractures (VAPOUR): a multicentre, randomised, double-blind, placebo-controlled trial. *Lancet*. 2016;388(10052):1408-1416.
28. Update of a prospective randomized multicenter IDE clinical trial comparing Cortoss and PMMA in vertebroplasty. Paper presented at: 2009 American Association of Neurological Surgeons (AANS) Annual Meeting; May 2-6, 2009; San Diego, Calif.
29. Vertebroplasty: Material Flow Distribution and Leak Detection in a Prospective Randomized Controlled FDA Study in PVP Comparing Cortoss to PMMA. Paper presented at: American Society of Neuroradiology (ASNR) 47th Annual Meeting; May 16 - 21, 2009; Vancouver, British Columbia, Canada.
30. A Prospective, Randomized, Controlled FDA-IDE Trial to Compare Long-Term Pain Results, Subsequent Fracture Rates, Injection Volume and Leak Patterns in patients Receiving Vertebroplasty [PVP] Using Cortoss® or PMMA for Osteoporotic Compression Fractures. Paper presented at: North American Spine Society (NASS) Annual Meeting; November 10 - 14, 2009; San Francisco, CA.
31. Berenson JR, Pflugmacher R, Jarzem P, Zonder JA, Tillman JB, Ashraf T, Vrionis FD. Final Results of the First Randomized Trial Comparing Balloon Kyphoplasty (BKP) to Non-Surgical Management Among Cancer Patients with Vertebral Compression Fractures: Marked Improvement in Back Function, Quality of Life and Pain in the BKP Arm. Paper presented at: American Society of Hematology: Poster Session: Myeloma-Therapy, Excluding Transplantaion Poster II; December 6, 2009; New Orleans, LA.
32. Gilula LA. Vertebral Augmentaiton: 2 year Clinical Experience in a Prospective Randomized Controlled FDA Study in Vertebroplasty Comparing Cortoss [C] to PMMA [P]. Paper presented at: American Society of Spine Radiology 2009; Lake Buena Vista, Florida.
33. Gilula LA. Subsequent Fractures Post-Vertebral Augmentation: Results from a Prospective Randomized FDA Trial Comparing Cortoss and PMMA in Osteoporotic Vertebral Compression Fractures (VCF's). Paper presented at: American Society of Spine Radiology Annual Symposium; Feb. 18-21, 2010; Las Vegas, NV.

34. Nunley P. A Comparison of Clinical Outcomes and Adjacent Level Fractures in Patients Receiving Vertebroplasty for Osteoporotic Compression Fractures Using Cortoss or PMMA: Prospective, Randomized Trial. Paper presented at: Congress of Neurosurgeons; October 26, 2009; New Orleans, LA.
35. Nunley P. Correlation of Fill Volume to Subsequent Fracture Rates in a Prospective Randomized Controlled FDA Study in PVP Comparing Cortoss (C) to PMMA (P). Paper presented at: American Association of Neuroradiology (AANS) Annual Meeting; May 1 - 5, 2010; Philadelphia, PA.
36. Syed MI. Effect of Age on Clinical Outcomes of Vertebroplasty: A Prospective Randomized Study Comparing Cortoss (C) and PMMA (P). Paper presented at: Society of Interventional Radiology 2009; San Diego, Calif.
37. Syed MI. Percutaneous Vertebroplasty: A Comparison of Material Characteristics and Clinical Results between Cortoss and PMMA in a Multi-center Vertebroplasty Paper presented at: Society of Interventional Radiology 35th Annual Scientific Meeting; March 13 - 18, 2010; Tampa, Fla.
38. Wardlaw D, Cummings SR, Van Meirhaeghe J, et al. Efficacy and safety of balloon kyphoplasty compared with non-surgical care for vertebral compression fracture (FREE): a randomised controlled trial. *Lancet*. 2009;373(9668):1016-1024.
39. Zhang K. Pre- and Post-Treatment Analgesia and Pain-Results in a 2 Year Randomized controlled Percutaneous Vertebroplasty Study. Paper presented at: 3rd Annual Lumbar Spine Research Society Meeting; April 8, 2010; Chicago, IL.
40. Berenson J, Pflugmacher R, Jarzem P, et al. Balloon kyphoplasty versus non-surgical fracture management for treatment of painful vertebral body compression fractures in patients with cancer: a multicentre, randomised controlled trial. *The Lancet. Oncology*. 2011;12(3):225-235.
41. Blasco J, Martinez-Ferrer A, Macho J, et al. Effect of vertebroplasty on pain relief, quality of life, and the incidence of new vertebral fractures: a 12-month randomized follow-up, controlled trial. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research*. 2012;27(5):1159-1166.
42. Chen D, An ZQ, Song S, Tang JF, Qin H. Percutaneous vertebroplasty compared with conservative treatment in patients with chronic painful osteoporotic spinal fractures. *Journal of clinical neuroscience : official journal of the Neurosurgical Society of Australasia*. 2014;21(3):473-477.
43. Farrokhi MR, Alibai E, Maghami Z. Randomized controlled trial of percutaneous vertebroplasty versus optimal medical management for the relief of pain and disability in acute osteoporotic vertebral compression fractures. *Journal of neurosurgery. Spine*. 2011;14(5):561-569.
44. Klazen CA, Lohle PN, de Vries J, et al. Vertebroplasty versus conservative treatment in acute osteoporotic vertebral compression fractures (Vertos II): an open-label randomised trial. *Lancet*. 2010;376(9746):1085-1092.
45. Liu J, Li X, Tang D, et al. Comparing pain reduction following vertebroplasty and conservative treatment for osteoporotic vertebral compression fractures: a meta-analysis of randomized controlled trials. *Pain physician*. 2013;16(5):455-464.
46. Rousing R, Andersen MO, Jespersen SM, Thomsen K, Lauritsen J. Percutaneous vertebroplasty compared to conservative treatment in patients with painful acute or subacute osteoporotic vertebral fractures: three-months follow-up in a clinical randomized study. *Spine (Phila Pa 1976)*. 2009;34(13):1349-1354.
47. Voormolen MH, Mali WP, Lohle PN, et al. Percutaneous vertebroplasty compared with optimal pain medication treatment: short-term clinical outcome of patients with subacute or chronic painful osteoporotic vertebral compression fractures. The VERTOS study. *AJNR Am J Neuroradiol*. 2007;28(3):555-560.
48. Anderson PA, Froysheter AB, Tontz WL, Jr. Meta-analysis of vertebral augmentation compared with conservative treatment for osteoporotic spinal fractures. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research*. 2013;28(2):372-382.
49. Cooper C. The epidemiology of fragility fractures: is there a role for bone quality? *Calcif Tissue Int*. 1993;53 Suppl 1:S23-26.
50. Cooper C, Atkinson EJ, Jacobsen SJ, O'Fallon WM, Melton LJ, 3rd. Population-based study of survival after osteoporotic fractures. *Am J Epidemiol*. 1993;137(9):1001-1005.
51. Riggs BL, Melton LJ, 3rd. Involutional osteoporosis. *N Engl J Med*. 1986;314(26):1676-1686.
52. Riggs BL, Melton LJ, 3rd. The worldwide problem of osteoporosis: insights afforded by epidemiology. *Bone*. 1995;17(5 Suppl):505S-511S.
53. Wasnich RD. Vertebral fracture epidemiology. *Bone*. 1996;18(3 Suppl):179S-183S.

54. Heaney RP. The natural history of vertebral osteoporosis. Is low bone mass an epiphenomenon? *Bone*. 1992;13 Suppl 2:S23-26.
55. McGraw JK, Cardella J, Barr JD, et al. Society of Interventional Radiology quality improvement guidelines for percutaneous vertebroplasty. *J Vasc Interv Radiol*. 2003;14(9 Pt 2):S311-315.
56. Silverman SL. The clinical consequences of vertebral compression fracture. *Bone*. 1992;13 Suppl 2:S27-31.
57. Lange A, Kasperk C, Alvares L, Sauermann S, Braun S. Survival and cost comparison of kyphoplasty and percutaneous vertebroplasty using German claims data. *Spine (Phila Pa 1976)*. 2014;39(4):318-326.
58. Khan OA, Brinjikji W, Kallmes DF. Vertebral augmentation in patients with multiple myeloma: a pooled analysis of published case series. *AJNR Am J Neuroradiol*. 2014;35(1):207-210.
59. Anselmetti GC, Manca A, Montemurro F, et al. Percutaneous vertebroplasty in multiple myeloma: prospective long-term follow-up in 106 consecutive patients. *Cardiovascular and interventional radiology*. 2012;35(1):139-145.
60. Hirsch JA, Hirsch AE, Jha R, et al. Practical management of malignant compression fractures. *Journal of neurointerventional surgery*. 2010;2(3):219-220.
61. Jha RM, Hirsch AE, Yoo AJ, Ozonoff A, Growney M, Hirsch JA. Palliation of compression fractures in cancer patients by vertebral augmentation: a retrospective analysis. *Journal of neurointerventional surgery*. 2010;2(3):221-228.
62. American College of Radiology. ACR practice parameter for continuing medical education (CME). 2016; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CME.pdf>. Accessed December 29, 2015.
63. American College of Radiology. ACR-SIR-SNIS-SPR practice parameter for interventional clinical practice and management. 2014; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/IRClin-Prac-Mgmt.pdf>. Accessed December 29, 2015.
64. International Electrotechnical Commission (2000) Report 60601. *Medical electrical equipment-Part 2-43: particular requirements for the safety of X-ray equipment for interventional procedures*. Geneva, Switzerland: International Electrotechnical Commission;2000.
65. American College of Radiology. ACR-SIR practice parameter for sedation/analgesia. 2015; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Sed-Analgesia.pdf>. Accessed December 29, 2015.
66. Amis ES, Jr., Butler PF, Applegate KE, et al. American College of Radiology white paper on radiation dose in medicine. *J Am Coll Radiol*. 2007;4(5):272-284.
67. Miller DL, Balter S, Wagner LK, et al. Quality improvement guidelines for recording patient radiation dose in the medical record. *J Vasc Interv Radiol*. 2004;15(5):423-429.
68. Stecker MS, Balter S, Towbin RB, et al. Guidelines for patient radiation dose management. *J Vasc Interv Radiol*. 2009;20(7 Suppl):S263-273.
69. American College of Radiology. ACR-SIR-SPR practice parameter for the reporting and archiving of interventional radiology procedures. 2014; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Reporting-Archiv.pdf>. Accessed December 29, 2015.
70. American College of Radiology. ACR-SIR practice parameter on informed consent for image-guided procedures. 2016; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/InformedConsent-ImagGuided.pdf>. Accessed December 29, 2015.
71. Hodler J, Peck D, Gilula LA. Midterm outcome after vertebroplasty: predictive value of technical and patient-related factors. *Radiology*. 2003;227(3):662-668.
72. Barbero S, Casorzo I, Durando M, et al. Percutaneous vertebroplasty: the follow-up. *Radiol Med*. 2008;113(1):101-113.
73. Calmels V, Vallee JN, Rose M, Chiras J. Osteoblastic and mixed spinal metastases: evaluation of the analgesic efficacy of percutaneous vertebroplasty. *AJNR Am J Neuroradiol*. 2007;28(3):570-574.
74. Jensen ME, McGraw JK, Cardella JF, Hirsch JA. Position statement on percutaneous vertebral augmentation: a consensus statement developed by the American Society of Interventional and Therapeutic Neuroradiology, Society of Interventional Radiology, American Association of Neurological Surgeons/Congress of Neurological Surgeons, and American Society of Spine Radiology. *AJNR Am J Neuroradiol*. 2007;28(8):1439-1443.
75. McDonald RJ, Trout AT, Gray LA, Dispenzieri A, Thielen KR, Kallmes DF. Vertebroplasty in multiple myeloma: outcomes in a large patient series. *AJNR Am J Neuroradiol*. 2008;29(4):642-648.

76. Muto M, Muto E, Izzo R, Diano AA, Lavanga A, Di Furia U. Vertebroplasty in the treatment of back pain. *Radiol Med*. 2005;109(3):208-219.
77. Jha RM, Yoo AJ, Hirsch AE, Growney M, Hirsch JA. Predictors of successful palliation of compression fractures with vertebral augmentation: single-center experience of 525 cases. *J Vasc Interv Radiol*. 2009;20(6):760-768.
78. Lovi A, Teli M, Ortolina A, Costa F, Fornari M, Brayda-Bruno M. Vertebroplasty and kyphoplasty: complementary techniques for the treatment of painful osteoporotic vertebral compression fractures. A prospective non-randomised study on 154 patients. *Eur Spine J*. 2009;18 Suppl 1:95-101.
79. McGirt MJ, Parker SL, Wolinsky JP, Witham TF, Bydon A, Gokaslan ZL. Vertebroplasty and kyphoplasty for the treatment of vertebral compression fractures: an evidenced-based review of the literature. *Spine J*. 2009;9(6):501-508.
80. Beall D, Chambers M, Thomas S, et al. EVOLVE: A prospective and multicenter evaluation of outcomes for quality of life, pain and activities of daily living for balloon kyphoplasty in the treatment of Medicare-eligible subjects with vertebral compression fractures. *JVIR*. 2017;28(2):Supplements, S25.
81. Barragan-Campos HM, Vallee JN, Lo D, et al. Percutaneous vertebroplasty for spinal metastases: complications. *Radiology*. 2006;238(1):354-362.
82. Caudana R, Renzi Brivio L, Ventura L, Aitini E, Rozzanigo U, Barai G. CT-guided percutaneous vertebroplasty: personal experience in the treatment of osteoporotic fractures and dorsolumbar metastases. *Radiol Med (Torino)*. 2008;113(1):114-133.
83. Layton KF, Thielen KR, Koch CA, et al. Vertebroplasty, first 1000 levels of a single center: evaluation of the outcomes and complications. *AJNR Am J Neuroradiol*. 2007;28(4):683-689.
84. Murphy KJ, Deramond H. Percutaneous vertebroplasty in benign and malignant disease. *Neuroimaging Clin N Am*. 2000;10(3):535-545.
85. Laredo JD, Hamze B. Complications of percutaneous vertebroplasty and their prevention. *Skeletal Radiol*. 2004;33(9):493-505.
86. Toy JO, Basques BA, Grauer JN. Morbidity, mortality, and readmission after vertebral augmentation: analysis of 850 patients from the American College of Surgeons National Surgical Quality Improvement Program database. *Spine (Phila Pa 1976)*. 2014;39(23):1943-1949.

Appendix A

Society of Interventional Radiology Standards of Practice Committee Classification of Complications by Outcome

Minor Complications

- A. No therapy, no consequence
- B. Nominal therapy, no consequence; includes overnight admission for observation only

Major Complications

- A. Require therapy, minor hospitalization (<48 hours)
- B. Require major therapy, unplanned increase in level of care, prolonged hospitalization (>48 hours)
- C. Have permanent adverse sequelae
- D. Result in death

*Practice parameters and technical standards are published annually with an effective date of October 1 in the year in which amended, revised or approved by the ACR Council. For practice parameters and technical standards published before 1999, the effective date was January 1 following the year in which the practice parameter or technical standard was amended, revised, or approved by the ACR Council.

Development Chronology for this Practice Parameter

2000 (Resolution 14)

Amended 2004 (Resolution 25)

Revised 2005 (Resolution 44)
Amended 2006 (Resolution 16g, 17, 34, 35, 36)
Revised 2009 (Resolution 25)
Revised 2011 (Resolution 40)
Revised 2012 (Resolution 6)
Amended 2014 (Resolution 39)
Revised 2017 (Resolution 16)
Amended 2018 (Resolution 44)
Amended 2019 (Resolution 23)