

Management of Vertebral Compression Fractures
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
1. Teasell R, Dittmer DK. Complications of immobilization and bed rest. Part 2: Other complications. [Review] [23 refs]. Can Fam Physician. 39:1440-2, 1445-6, 1993 Jun.	Review/Other-Dx	N/A	To summarize the complications of immobilization and bed rest.	No results stated in abstract.	4
2. Radvany MG, Murphy KJ, Millward SF, et al. Research reporting standards for percutaneous vertebral augmentation. J Vasc Interv Radiol. 2009; 20(10):1279-1286.	Review/Other-Dx	N/A	Recommendations to improve the quality and relevance of research reporting of vertebral augmentation.	The imaging modalities used to perform vertebral augmentation should be described. Patient positioning, the route/approach, and the point of needle entry into the vertebral body should be described. Published studies on vertebral augmentation have been limited by nonstandardized reporting, lack of long-term follow-up, and use of surrogate outcome measures.	4
3. American College of Radiology. ACR Appropriateness Criteria®: Osteoporosis and Bone Mineral Density. Available at: https://acsearch.acr.org/docs/69358/Narrative/ .	Review/Other-Dx	N/A	Evidence-based guidelines to assist referring physicians and other providers in making the most appropriate imaging or treatment decision for Osteoporosis and bone mineral density.	N/A	4

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4. Kim DH, Vaccaro AR. Osteoporotic compression fractures of the spine; current options and considerations for treatment. <i>Spine J.</i> 2006; 6(5):479-487.	Review/Other-Tx	N/A	To review current principles in the evaluation and treatment of osteoporotic compression fractures of the spine.	Over 200 separate scientific and clinical studies addressing the epidemiology, pathophysiology, diagnosis, and treatment of osteoporotic vertebral compression fractures were reviewed. Osteoporotic vertebral compression fractures are a common presenting complaint to spinal care specialists. Thorough differential diagnosis should be considered before attributing fractures to osteoporosis. Appropriate evaluation and medical treatment of underlying osteoporosis should be recommended or instituted. Nonsurgical management of the spinal fracture should focus on pain control and maximizing functional outcome. The role of surgical treatment remains controversial and should be reserved for patients who fail initial nonsurgical management options.	4
5. Lane NE. Epidemiology, etiology, and diagnosis of osteoporosis. <i>Am J Obstet Gynecol.</i> 2006; 194(2 Suppl):S3-11.	Review/Other-Dx	N/A	To review the osteoporotic risk factors and objective measures of BMD that can help to identify patients who will benefit from intervention and, thus, can potentially reduce the morbidity and mortality associated with osteoporosis-associated fractures in this population.	The clinical consequences and economic burden of osteoporosis indicate a need for intervention in women at high-risk. Many risk factors are associated with osteoporosis and fracture, including: low-peak bone mass achieved during growth-hormonal factors, the use of certain drugs, cigarette smoking, low physical activity, low intake of calcium and vitamin D, race, small body size, personal or family history of fracture. All of these factors should be taken into account when assessing the risk of fracture to determine which patients require further assessment and/or treatment.	4

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6. Siris ES, Brenneman SK, Barrett-Connor E, et al. The effect of age and bone mineral density on the absolute, excess, and relative risk of fracture in postmenopausal women aged 50-99: results from the National Osteoporosis Risk Assessment (NORA). <i>Osteoporos Int.</i> 2006; 17(4):565-574.	Review/Other-Tx	170,083 women	To evaluate the effect of age and BMD on the absolute, excess, and relative risk for osteoporotic fractures at the hip, wrist, forearm, spine, and rib within 3 years of peripheral BMD testing in postmenopausal women over a wide range of postmenopausal ages.	Absolute risk of fracture increased with age for all fracture sites. This age-effect was most evident for hip fracture — both the incidence and the excess risk of hip fracture — for women with low BMD increased at least twofold for each decade increase in age. The relative risk for any fracture per 1 SD decrease in BMD was similar across age groups ($P>0.07$). Women with low BMD (T-score <-1.0) had a similar relative risk for fracture regardless of age. At any given BMD, not only the absolute fracture risk but also the excess fracture risk increased with advancing age. Relative risk of fracture for low bone mass was consistent across all age groups from 50 to 99 years.	4
7. Bigos SJ, Bowyer OR, Braen GR, et al. Acute Low Back Problems in Adults. Clinical Practice Guideline No. 14. AHCPR Publication No. 95-0642. Rockville, MD: Agency for Health Care Policy and Research, Public Health Service, U.S. Department of Health and Human Services. December 1994.	Review/Other-Dx	N/A	Findings and recommendations on the assessment and treatment of adults with acute low back problems are presented in this practice guideline.	n/a	4
8. Schajowicz F. Aneurysmal bone cyst. In: Schajowicz F, ed. <i>Histologic Typing of Bone Tumors</i> . 2nd ed. Berlin, Germany: Springer-Verlag; 1992:37.	Review/Other-Dx	N/A	Book chapter.	N/A	4

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9. Kallmes DF, Jensen ME. Percutaneous vertebroplasty. <i>Radiology</i> . 2003; 229(1):27-36.	Review/Other-Tx	N/A	To review specific areas where the approach to VP has changed substantially over the past several years, with an emphasis on technical changes and clinical research.	PVP has been embraced by the North American radiology community within the past decade. Although the basic principles behind VP remain unchanged, the technical aspects have been dramatically affected by operator experience, product development, and critical evaluation of large series of patients. Although questions concerning the safety of VP have been answered, its efficacy and durability remain clouded owing to the lack of randomized controlled trials and uncertainty over the role of the placebo effect.	4
10. 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. <i>Spine J</i> . 2009; 9(6):501-508.	Review/Other-Tx	74 studies: 1 – level I study; 3 – level II studies; 70 – level IV case series	A systematic review to determine the level of evidence supporting VP or KP for the treatment of VCFs.	The level of evidence available to date is adequate to suggest that VP results in greater pain relief acutely after intervention compared with that in medical management alone.	4
11. Fourney DR, Frangou EM, Ryken TC, et al. Spinal instability neoplastic score: an analysis of reliability and validity from the spine oncology study group. <i>J Clin Oncol</i> . 29(22):3072-7, 2011 Aug 01.	Observational-Dx	30 patients	To determine the interobserver reliability, intraobserver reliability, and predictive validity of the Spinal Instability Neoplastic Score (SINS).	The kappa statistics for interobserver reliability were 0.790, 0.841, 0.244, 0.456, 0.462, and 0.492 for the fields of location, pain, bone quality, alignment, vertebral body collapse, and posterolateral involvement, respectively. The statistics for intraobserver reliability were 0.806, 0.859, 0.528, 0.614, 0.590, and 0.662 for the same respective fields. Intraclass correlation coefficients for inter- and intraobserver reliability of total SINS score were 0.846 (95% CI, 0.773 to 0.911) and 0.886 (95% CI, 0.868 to 0.902), respectively. The statistic for predictive validity was 0.712 (95% CI, 0.676 to 0.766).	3

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12. Faruqi S, Tseng CL, Whyne C, et al. Vertebral Compression Fracture After Spine Stereotactic Body Radiation Therapy: A Review of the Pathophysiology and Risk Factors. <i>Neurosurgery</i> 2017:[E-pub ahead of print].	Meta-analysis	11 studies	To summarize the data from the multiple studies that have been published, addressing the risk and predictive factors for VCF post-SBRT.	A total of 11 studies were identified, reporting both the risk of VCF post-SBRT and an analysis of risk factors based on univariate and multivariate analysis. A total of 2911 spinal segments were treated with a crude VCF rate of 13.9%. The most frequently identified risk factors on multivariate analysis were: lytic disease (hazard ratio [HR] range, 2.76-12.2), baseline VCF prior to SBRT (HR range, 1.69-9.25), higher dose per fraction SBRT (HR range, 5.03-6.82), spinal deformity (HR range, 2.99-11.1), older age (HR range, 2.15-5.67), and more than 40% to 50% of vertebral body involved by tumor (HR range, 3.9-4.46). In the 9 studies that specifically reported on the use of post-SBRT surgical procedures, 37% of VCF had undergone an intervention (range, 11%-60%).	Good
13. Bilsky MH, Laufer I, Fourney DR, et al. Reliability analysis of the epidural spinal cord compression scale. <i>J Neurosurg Spine</i> . 13(3):324-8, 2010 Sep.	Observational-Dx	25 cervical or thoracic spinal tumors	To determine the reliability and validity of a 6-point, MR imaging-based grading system for ESCC.	The inter- and intrarater reliability ranged from good to excellent when surgeons were asked to rate the degree of spinal cord compression using T2-weighted axial images. The T2-weighted images were superior indicators of ESCC compared with T1-weighted images with and without Gd.	4
14. Korovessis P, Vardakastanis K, Vitsas V, Syrimpeis V. Is Kiva implant advantageous to balloon kyphoplasty in treating osteolytic metastasis to the spine? Comparison of 2 percutaneous minimal invasive spine techniques: a prospective randomized controlled short-term study. <i>Spine</i> . 39(4):E231-9, 2014 Feb 15.	Experimental-Dx	47 patients	To compare cement leakage rate and efficacy for vertebral body restoration of balloon kyphoplasty (BK) versus Kiva novel implant with polymethylmethacrylate (PMMA) for treating osteolytic vertebral body metastasis.	No patient survived after 3 months. Asymptomatic PMMA leakage occurred in 4 (9.3%) vertebrae in the BK group solely (2 to the spinal canal, in Tomita grade 3 osteolysis) Anterior, posterior and middle vertebral body height ratio, Gardner angle improved insignificantly in both groups. Visual analogue scale and Oswestry Disability Index improved postoperatively similarly in both groups ($P < 0.001$).	1

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<p>15. Ortiz AO.. Use and evaluation of a semi-permeable mesh implant in vertebral augmentation for the treatment of painful osteoporotic vertebral compression fractures. <i>Journal of Neurointerventional Surgery</i>. 8(3):328-32, 2016 Mar.</p>	<p>Experimental-Dx</p>	<p>17 patients.</p>	<p>To assess the efficacy of a semi-permeable mesh implant in the treatment of painful thoracic and lumbar osteoporotic vertebral compression fractures.</p>	<p>17 patients were included in this retrospective study; 12 women and 5 men, with an average age of 78.6 years. Each patient had one level treated with the mesh implant; 4 thoracic levels and 13 lumbar levels. The 10x15 mm implant was used in 13 treated vertebrae, including the two thoracic vertebrae; the 10x20 mm implant was used to treat 3 lumbar vertebrae, and one 10x25 mm implant was used to treat an L1 vertebra. An average of 2.4 mL of acrylic bone cement was injected, and there was fluoroscopic evidence of a small amount of cement leakage in one case. No patient related complications were seen and there were no device failures. All patients, followed-up to at least 3 weeks, showed significant pain relief. The average pretreatment numeric pain score of 9 and ODI of 50 decreased to an average post-treatment score of 0.6 and 12, respectively (p<0.001)</p>	<p>2</p>
<p>16. Renaud C.. Treatment of vertebral compression fractures with the cranio-caudal expandable implant SpineJack: Technical note and outcomes in 77 consecutive patients. <i>Orthopaedics & traumatology, surgery & research</i>. 101(7):857-9, 2015 Nov.</p>	<p>Review/Other-Dx</p>	<p>N/A</p>	<p>To report the experience acquired with SpineJack® between October 2007 and December 2012.</p>	<p>No results stated in abstract.</p>	<p>4</p>

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17. Tutton SM, Pflugmacher R, Davidian M, Beall DP, Facchini FR, Garfin SR. KAST Study: The Kiva System As a Vertebral Augmentation Treatment-A Safety and Effectiveness Trial: A Randomized, Noninferiority Trial Comparing the Kiva System With Balloon Kyphoplasty in Treatment of Osteoporotic Vertebral Compression Fractures. <i>Spine (Phila Pa 1976)</i> . 2015;40(12):865-875.	Experiment al-Tx	300 subjects	To demonstrate noninferiority of the Kiva system to balloon kyphoplasty (BK) with respect to the composite primary endpoint.	A mean improvement of 70.8 and 71.8 points in the visual analogue scale score and 38.1 and 42.2 points in the Oswestry Disability Index was noted in Kiva and BK, respectively. No device-related serious adverse events occurred. Despite significant differences in risk factors favoring the control group at baseline, the primary endpoint demonstrated noninferiority of Kiva to BK. Analysis of secondary endpoints revealed superiority with respect to cement use and site-reported extravasation and a positive trend in adjacent level fracture warranting further study.	1
18. Chen D, An ZQ, Song S, Tang JF, Qin H. Percutaneous vertebroplasty compared with conservative treatment in patients with chronic painful osteoporotic spinal fractures. <i>Journal of Clinical Neuroscience</i> . 21(3):473-7, 2014 Mar.	Experiment al-Tx	96 patients.	To compare the efficacy of percutaneous vertebroplasty (PVP) and conservative treatment (CT) for pain relief and functional outcome in patients with chronic compression fractures and persistent pain.	Pain relief and functional outcomes were significantly better in Group A than in Group B, as determined by visual analogue scale scores, Oswestry Disability Index scores, and Roland Morris Disability scores at 1 week, 1 month, 3 months, 6 months and 1 year (all $p < 0.001$). The final clinical follow-up assessment indicated complete pain relief in 39 Group A patients and 15 Group B patients ($p < 0.001$). PVP for patients with chronic compression fractures and persistent severe pain was associated with better pain relief and improved functional outcomes at 1 year compared to CT.	1

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19. 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. <i>Lancet</i> . 388(10052):1408-1416, 2016 Oct 01.	Experimental-Tx	120 patients	To understand better the safety and effectiveness of vertebroplasty for patients with painful osteoporotic fractures.	24 (44%) patients in the vertebroplasty group and 12 (21%) in the control group had an NRS pain score below 4 out of 10 at 14 days (between-group difference 23 percentage points, 95% CI 6-39; p=0.011). Three patients in each group died from causes judged unrelated to the procedure. There were two serious adverse events in each group, related to the procedure (vertebroplasty group) and the fracture (control group).	1
20. 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. <i>Journal of Neurosurgery Spine</i> . 14(5):561-9, 2011 May.	Experimental-Dx	82 patients	To assess the short- and long-term effect of percutaneous vertebroplasty (PV) on pain relief and quality of life (QOL) in comparison with optimal medical therapy (OMT) in patients with osteoporotic vertebral compression fractures (VCFs).	The authors found a statistically significant improvement in pain in the PV group compared with the OMT group at 1 week (difference -3.1, 95% CI -3.72 to -2.28; p < 0.001). The QOL improved significantly in the PV group (difference -14, 95% CI -15 to -12.82; p < 0.028). One week after PV, the average vertebral body height (VBH) restoration was 8 mm and the correction of deformity was 8 degrees. The incidence of new fractures in the OMT group (13.3%) was higher than in the PV group (2.2%; p < 0.01).	1
21. Chen C, Bian J, Zhang W, Zhang W, Zhao C, Wei H. Unilateral versus bilateral vertebroplasty for severe osteoporotic vertebral compression fractures. <i>Journal of Spinal Disorders & Techniques</i> . 27(8):E301-4, 2014 Dec.	Experimental-Dx	39 patients	To assess and compare the clinical outcomes and complications of unilateral and bilateral vertebroplasty (VP) in treating severe vertebral compression fractures.	Significant improvement on the visual analog scale and Oswestry disability index scores were noted in each group, and there were no significant differences between the 2 groups. Cement leakage was seen more in bilateral VP.	1

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22. Dohm M, Black CM, Dacre A, Tillman JB, Fueredi G, KAVIAR investigators. A randomized trial comparing balloon kyphoplasty and vertebroplasty for vertebral compression fractures due to osteoporosis. <i>Ajnr: American Journal of Neuroradiology</i> . 35(12):2227-36, 2014 Dec.	Observational-Dx	404 patients	To compare the efficacy and safety of balloon kyphoplasty and vertebroplasty.	The average age of patients was 75.6 years (77.4% female). Mean procedure duration was longer for kyphoplasty (40.0 versus 31.8 minutes, P .001). At 12 months, 7.8% fewer patients with kyphoplasty (50/140 versus 57/131) had subsequent radiographic fracture, and there were 8.6% fewer at 24 months (54/110 versus 64/111). The results were not statistically significant (P .21). When we used time to event for new clinical fractures, kyphoplasty approached statistical significance in longer fracture-free survival (Wilcoxon, P .0596). Similar pain and function improvements were observed. Computed tomography (CT) demonstrated lower cement extravasation for kyphoplasty (157/214 versus 164/201 levels treated, P .047). For kyphoplasty versus vertebroplasty, common adverse events within 30 postoperative days were procedural pain (12/191, 9/190), back pain (14/191, 28/190), and new vertebral fractures (9/191, 17/190); similar 2-year occurrence of device-related cement embolism (1/191, 1/190), procedural pain (3/191, 3/190), back pain (2/191, 3/190), and new vertebral fracture (2/191, 2/190) was observed.	2

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<p>23. Du J, Li X, Lin X. Kyphoplasty versus vertebroplasty in the treatment of painful osteoporotic vertebral compression fractures: two-year follow-up in a prospective controlled study. <i>Acta Orthopaedica Belgica</i>. 80(4):477-86, 2014 Dec.</p>	<p>Experimental-Dx</p>	<p>112 patients</p>	<p>To compare the 2-year clinical and radiographic outcomes of kyphoplasty and vertebroplasty in the treatment of painful osteoporotic Vertebral compression fractures (VCFs), and to investigate if either of kyphoplasty or vertebroplasty provides a better treatment outcome than the other procedure.</p>	<p>The follow-up rate was 73.3% in the kyphoplasty group and 80.8% in the vertebroplasty group (P = 0.737). There were no significant differences between the 2 groups with regard to improvement in VAS and ODI scores (P > 0.05) at all postoperative intervals. Both treatment groups achieved marked vertebral height restoration and kyphotic angle reduction, but the radiographic parameters were significantly better in the kyphoplasty group (P < 0.05). The incidence of asymptomatic cement leakage per treated vertebrae in the kyphoplasty group was 11.4% versus 31% in the vertebroplasty group (P < 0.001). Three adjacent level fractures in the kyphoplasty group and 2 in the vertebroplasty group occurred during 2-year follow-up, and no difference in patient satisfaction was detected between the 2 groups.</p>	<p>2</p>

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<p>24. Evans AJ, Kip KE, Brinjikji W, et al. Randomized controlled trial of vertebroplasty versus kyphoplasty in the treatment of vertebral compression fractures. <i>Journal of Neurointerventional Surgery</i>. 8(7):756-63, 2016 Jul.</p>	<p>Observational-Dx</p>	<p>115 patients</p>	<p>To present the results of a randomized controlled trial evaluating the efficacy of vertebroplasty versus kyphoplasty in treating vertebral body compression fractures.</p>	<p>115 subjects were enrolled in the trial with 59 (51.3%) randomly assigned to kyphoplasty and 56 (48.7%) assigned to vertebroplasty. Mean (SD) pain scores at baseline, 3 days, 30 days, and 1 year for kyphoplasty versus vertebroplasty were 7.4 (1.9) vs 7.9 (2.0), 4.1 (2.8) vs 3.7 (3.0), 3.4 (2.5) vs 3.6 (2.9), and 3.0 (2.8) vs 2.3 (2.6), respectively (p>0.05 at all time points). Mean (SD) Roland-Morris Disability Questionnaire (RMDQ) scores at baseline, 3 days, 30 days, 180 days, and 1 year were 17.3 (6.6) vs 16.3 (7.4), 11.8 (7.9) vs 10.9 (8.2), 8.6 (7.2) vs 8.8 (8.5), 7.9 (7.4) vs 7.3 (7.7), 7.5 (7.2) vs 6.7 (8.0), respectively (p>0.05 at all time points). For baseline to 12-month assessment in average pain and RMDQ scores, the standardized effect size between kyphoplasty and vertebroplasty was small at -0.36 (95% CI -1.02 to 0.31) and -0.04 (95% CI -1.68 to 1.60), respectively.</p>	<p>2</p>

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25. Liu JT, Li CS, Chang CS, Liao WJ. Long-term follow-up study of osteoporotic vertebral compression fracture treated using balloon kyphoplasty and vertebroplasty. <i>Journal of Neurosurgery Spine</i> . 23(1):94-8, 2015 Jul.	Observational-Dx	100 patients	To determine whether these clinical outcomes persist in the long term, they continued to observe the patients from their short-term study over a longer-term period.	The duration of the follow-up period was 5 years. Vertebral body height, kyphotic wedge angle, and visual analog scale (VAS) score were not evidently altered. Eight patients in the kyphoplasty group had an adjacent fracture after the procedure, whereas 7 patients in the vertebroplasty group had an adjacent fracture after the procedure. These adjacent fractures occurred within 1 year of surgery in both treatment groups except in 1 kyphoplasty-treated patient in whom the adjacent fracture was noted 16 months after treatment. Three patients in the vertebroplasty group had a nonadjacent fracture, and 4 patients in the kyphoplasty group had a nonadjacent fracture. The link between angular correction and the occurrence of adjacent fracture was statistically significant in the vertebroplasty group.	2
26. Zhang L, Liu Z, Wang J, et al. Unipedicular versus bipedicular percutaneous vertebroplasty for osteoporotic vertebral compression fractures: a prospective randomized study. <i>BMC Musculoskeletal Disorders</i> . 16:145, 2015 Jun 14.	Experimental-Dx	58 patients	To compare unipedicular versus bipedicular percutaneous vertebroplasty for osteoporotic vertebral compression fractures.	The mean operative and exposure time to X-rays in the unipedicular percutaneous vertebroplasty (PVP) group was less than that of the bipedicular group ($p < 0.05$). No statistically significant differences were observed in the visual analogue scale (VAS) score, Oswestry disability index (ODI) score, SF-36 score, cement leakage rate or vertebral height restoration between the two groups ($p > 0.05$).	1
27. Zhao DH, Chen K, Zhu J, Yang X, Dong F, Wang WB. Postoperative Functional Evaluation of Percutaneous Vertebroplasty Compared With Percutaneous Kyphoplasty for Vertebral Compression Fractures. <i>American Journal of Therapeutics</i> . 23(6):e1381-e1390, 2016 Nov/Dec.	Meta-analysis	10 studies	To explore the postoperative functional recovery efficacies of percutaneous vertebroplasty (PVP) and percutaneous kyphoplasty (PKP) in the treatment of vertebral compression fractures (VCFs).	No results stated in abstract.	Good

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28. Brown DB, Gilula LA, Sehgal M, Shimony JS. Treatment of chronic symptomatic vertebral compression fractures with percutaneous vertebroplasty. <i>AJR Am J Roentgenol.</i> 182(2):319-22, 2004 Feb.	Observational-Dx	41 patients	To report the experience of treating chronic vertebral fractures with vertebroplasty.	Thirty-three (80%) of the 41 patients in the study group had improvement in pain—seven (17%) had complete and 26 (63%) had partial relief. Forty-five (92%) of the 49 control group patients had improvement in pain—24 (49%) had complete and 21 (43%) had partial relief. The number of patients achieving partial or complete relief of pain was not statistically different between groups ($p > 0.05$), although complete relief was significantly more frequent in the control group ($p = 0.002$). Twenty patients (49%) in the study group versus 34 patients (69%) in the control group had improved mobility after vertebroplasty ($p = 0.047$). Patients with fractures 12 months 1 day–24 months old had improvement in mobility similar to that in patients in the control group ($p = 0.962$). Fractures more than 24 months 1 day old were associated with significantly less improvement in mobility ($p = 0.006$).	2
29. Nieuwenhuijse MJ, van Erkel AR, Dijkstra PD. Percutaneous vertebroplasty for subacute and chronic painful osteoporotic vertebral compression fractures can safely be undertaken in the first year after the onset of symptoms. <i>Journal of Bone & Joint Surgery - British Volume.</i> 94(6):815-20, 2012 Jun.	Observational-Dx	115 patients	To investigate the relationship between the onset of symptoms - the time from fracture - and the efficacy of vertebroplasty in 115 patients with 216 painful subacute or chronic osteoporotic vertebral compression fractures (OVCFs) (mean time from fracture 6.0 months (sd 2.9)).	It was found that there was an immediate and sustainable improvement in the level of back pain and health-related quality of life (HRQoL) after vertebroplasty, which was independent of the time from fracture. Greater time from fracture was associated with neither worse pre-operative conditions nor increased vertebral deformity, nor with the presence of an intravertebral cleft.	3

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30. Syed MI, Shaikh A, Cortoss Study Group. Does age of fracture affect the outcome of vertebroplasty? Results from data from a prospective multicenter FDA IDE study. <i>Journal of Vascular & Interventional Radiology</i> . 23(11):1416-22, 2012 Nov.	Experimental-Dx	256 patients	To evaluate whether the age of a fracture is a variable that can identify patients for whom vertebroplasty would be most beneficial.	A fracture age of 12 weeks or less versus greater than 12 weeks did not affect outcomes, with patients in both groups achieving equivalent benefit after vertebroplasty. Patients with a fracture age of 6 weeks or less had a slightly improved benefit at 3 months after vertebroplasty compared with those having a fracture age of greater than 6 weeks, but the benefit beyond 3 months was the same.	1
31. Venmans A, Klazen CA, Lohle PN, Mali WP, van Rooij WJ. Natural history of pain in patients with conservatively treated osteoporotic vertebral compression fractures: results from VERTOS II. <i>AJNR Am J Neuroradiol</i> . 33(3):519-21, 2012 Mar.	Observational-Dx	95 patients	To analyze the conservatively treated patients from VERTOS II. In particular, to assess the proportion of patients who developed chronic back pain.	During 1 year of follow-up, 57 of 95 patients (60%) had sufficient pain relief with Visual Analog Scale (VAS) scores ≤ 3 . Thirty-eight patients (40%) still had pain with VAS-scores ≥ 4 at the last follow-up interval of 12 months, despite the use of higher class pain medication. Statistical analysis showed no risk factors.	2
32. American College of Radiology. ACR-ASNR-ASSR-SIR-SNIS Practice Parameter for the Performance of Vertebral Augmentation. Available at: https://www.acr.org/~media/ACR/Documents/PGTS/guidelines/Vertebral_Augmentation.pdf .	Review/Other-Dx	N/A	To review the practice parameter for the performance of vertebral augmentation.	No results stated in abstract.	4

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33. 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). <i>J Vasc Interv Radiol.</i> 2014;25(2):171-181.	Review/Other-Tx	N/A	Position statement on percutaneous vertebral augmentation.	No results stated in abstract.	4
34. Yang PL, He XJ, Li HP, Zang QJ, Wang GY. Image-guided minimally invasive percutaneous treatment of spinal metastasis. <i>Experimental Ther. Med.</i> 13(2):705-709, 2017 Feb.	Observational-Dx	42 patients	To evaluate the efficacy and safety of image-guided minimally invasive percutaneous treatment of spinal metastases.	After the most suitable treatment was used, the biomechanical stability of the spine was increased, the pain caused by spinal metastases within 6 weeks was significantly reduced, while the daily activities and quality of life were improved. The mean progression-free survival of tumors was 330±54 days, and no associated complications occurred.	2
35. Parizel PM, van der Zijden T, Gaudino S, et al. Trauma of the spine and spinal cord: imaging strategies. <i>Eur Spine J.</i> 2010; 19 Suppl 1:S8-17.	Review/Other-Dx	N/A	To present a comprehensive overview of the classification of vertebral fractures, based on morphology (e.g., wedge, (bi)concave, or crush fractures) or on the mechanism of injury (flexion-compression, axial compression, flexion-distraction, or rotational fracture-dislocation lesions).	No results stated in abstract.	4

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36. Nairn RJ, Binkhamis S, Sheikh A. Current perspectives on percutaneous vertebroplasty: current evidence/controversies, patient selection and assessment, and technique and complications. <i>Radiol Res Pract.</i> 2011; 2011:175079.	Review/Other-Tx	N/A	To review recent controversies surrounding the evidence for VP in osteoporotic-associated VP compression fractures, and to describe a comprehensive step-by-step practical guide to performing VP.	Prompt assessment of PVP candidates is integral to successfully performing the procedure. The interventionist must take responsibility for reviewing imaging, taking a thorough history and examining the patient. PVP is usually technically straight forward and safe as long as a clear, reproducible, step-by-step approach is employed. Serious complications are uncommon and pain relief induced is often considerable.	4
37. Diekhoff T, Hermann KG, Pumberger M, Hamm B, Putzier M, Fuchs M. Dual-energy CT virtual non-calcium technique for detection of bone marrow edema in patients with vertebral fractures: A prospective feasibility study on a single-source volume CT scanner. <i>European Journal of Radiology.</i> 87:59-65, 2017 Feb.	Observational-Dx	9 patients	To determine the reliability of single-source dual-energy computed tomography (DECT) in detecting vertebral bone marrow edema (BME) using magnetic resonance imaging (MRI) as standard of reference.	Fourteen target vertebrae with a radiographic height loss were identified; eight of them showed BME on MRI, while DECT identified BME in 7 instances. There were no false positive virtual non-calcium images, resulting in a sensitivity of 0.88 (0.75–1.0 among all readers) and specificity of 1.0 (0.81–1.0). Interrater agreement was inferior for DECT (= 0.63–0.89) compared to MRI (= 0.9–1.0). Intervertebral ratio in VNC images strongly correlated with short-tau inversion recovery (r = 0.87) and inversely with T1 (-0.89). Signal-to-noise ratio (SNR) (0.2 +/- 0.2 in Virtual non-calcium (VNC) and 16.7 +/- 7.3 in short tau inversion recovery (STIR)) and contrast-to-noise ratio (CNR) (0.2 +/- 0.3 and 7.1 +/- 6.3) values were inferior in VNC.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
38. Karaca L, Yuceler Z, Kantarci M, et al. The feasibility of dual-energy CT in differentiation of vertebral compression fractures. Br J Radiol. 89(1057):20150300, 2016.	Observational-Dx	26 patients	To prospectively evaluate the ability of dual-energy computed tomography (DECT), compared with magnetic resonance imaging (MRI), to identify vertebral compression fractures in acute trauma patients.	Magnetic resonance imaging (MRI) revealed a total of 47 vertebrae (22.4% of all vertebrae) and DECT revealed 44 vertebrae (21.0% of all vertebrae) with oedema. Using MRI as the reference standard, DECT had sensitivity, specificity, positive-predictive value, negative-predictive value and accuracy of 89.3, 98.7, 95.4, 96.9 and 96.6%, respectively. With respect to establishing the presence of oedema, the interobserver agreement was almost perfect (k50.82), and the intraobserver agreement was substantial (k50.80).	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
<p>39. Kaup M, Wichmann JL, Scholtz JE, et al. Dual-Energy CT-based Display of Bone Marrow Edema in Osteoporotic Vertebral Compression Fractures: Impact on Diagnostic Accuracy of Radiologists with Varying Levels of Experience in Correlation to MR Imaging. <i>Radiology</i>. 280(2):510-9, 2016 Aug.</p>	<p>Observational-Dx</p>	<p>49 patients</p>	<p>To evaluate whether a dual-energy (DE) computed tomographic (CT) virtual noncalcium technique can improve the detection rate of acute thoracolumbar vertebral compression fractures in patients with osteoporosis compared with that at magnetic resonance (MR) imaging depending on the level of experience of the reading radiologist.</p>	<p>Sixty-two fractures were classified as fresh and 52 as old at MR imaging. The diagnostic performance of all readers in the detection of fresh fractures improved with the addition of virtual noncalcium reconstructions compared with that with conventional CT alone. Although the diagnostic accuracy of the least experienced reader with virtual noncalcium CT (accuracy with CT alone, 61%; accuracy with virtual noncalcium technique, 83%) was within the range of that of the most experienced reader with CT alone, the latter improved his accuracy with the noncalcium technique (from 81% to 95%), coming close to that with MR imaging. The number of vertebrae rated as unclear decreased by 59%–90% or from 15–53 to 2–13 in absolute numbers across readers. The number of patients potentially referred to MR imaging decreased by 36%–87% (from 11–23 to 2–10 patients). Considering the gain in true decisions with the virtual noncalcium technique on a patient level, between 12 (most experienced reader) and 17 (least experienced reader) MR examinations could have been avoided.</p>	<p>2</p>

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
40. Benz BK, Gemery JM, McIntyre JJ, Eskey CJ. Value of immediate preprocedure magnetic resonance imaging in patients scheduled to undergo vertebroplasty or kyphoplasty. <i>Spine (Phila Pa 1976)</i> . 2009; 34(6):609-612.	Review/Other-Dx	194 patients	To determine the incidence of additional VCFs diagnosed with repeat MRI immediately before VP or KP.	A total of 14 new fractures in 11 patients were discovered on the immediate preprocedure MRI. Of these 14, 6 had <15% loss of height, making them potentially occult on radiographs; 3 fractures developed in 2 patients who had no change in back pain. In select candidates for VP or KP, a repeat preprocedure MRI obtained within 1 week can help ensure that all painful fractures are treated. There is demonstrable value in this protocol for patients with an imaging evaluation over 3 months old or who have had any change in symptoms since the initial imaging workup.	4
41. Ma X, Wang LX, Wang HL, Jiang L, Lu FZ, Jiang JY. Value of preoperative magnetic resonance imaging measurements in thoracic percutaneous vertebroplasty using unilateral. <i>Chin Med J (Engl)</i> . 2010; 123(21):2983-2988.	Observational-Tx	40 patients	To assess the value of preoperative MRI measurements for PVP using a unilateral puncture.	The average time of a single vertebra operation in groups A and B were (34.7 +/- 5.4) and (23.3 +/- 4.2) minutes, respectively. In groups A and B, the success rates of puncture were 74.1% and 91.7%, respectively. Postoperative reduction of the average VAS scores in groups A and B at 3 and 12 months post-surgery were 5.8 +/- 2.1, 6.1 +/- 1.8, 6.1 +/- 2.0, and 6.2 +/- 1.6, respectively. However, the ODI increase was 41.6% +/- 5.7%, 40.6% +/- 6.0%, 46.3% +/- 5.2%, 46.1% +/- 6.7%. Paired t test evaluation of the values above showed a significant difference in the time of single-vertebra operation and the success rates between groups A and B (P<0.05), but no significant difference was seen in the reduction of VAS scores and ODI (P>0.05). There was no statistically significant difference in the complication rate between the two groups.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
42. Spiegl UJ, Beisse R, Hauck S, Grillhosl A, Buhren V. Value of MRI imaging prior to a kyphoplasty for osteoporotic insufficiency fractures. <i>Eur Spine J.</i> 2009; 18(9):1287-1292.	Review/Other-Dx	28 patients	To evaluate the additional value of preoperative MRI.	Diagnostic benefits of an MRI scan before performing a KP are prevalent. For 16 out of 28 patients, the therapeutic plan was changed because of the information obtained by preoperative MRI. Preoperative MRI helped to generate the correct surgical strategy, by demonstrating the correct location of injury and by detecting concomitant diseases.	4
43. Park SY, Lee SH, Suh SW, Park JH, Kim TG. Usefulness of MRI in determining the appropriate level of cement augmentation for acute osteoporotic vertebral compression fractures. <i>Journal of Spinal Disorders & Techniques.</i> 26(3):E80-5, 2013 May.	Observational-Dx	168 patients	To evaluate the usefulness of magnetic resonance imaging (MRI) for diagnosing appropriate acute lesions before a percutaneous cement augmentation technique.	The mean age of the study participants was 68.9 years. Forty-nine patients were male and 119 were female. In the single group, the concordance rate of diagnosis was 77% (97/125) and the discordance rate was 23% (28/125). In the multiple group, the discordance rate was 65% (28/43). There was a significantly higher rate of misdiagnosis in the multiple group compared with the single group ($P<0.01$).	2
44. Yang HL, Wang GL, Niu GQ, et al. Using MRI to determine painful vertebrae to be treated by kyphoplasty in multiple-level vertebral compression fractures: a prospective study. <i>Journal of International Medical Research.</i> 36(5):1056-63, 2008 Sep-Oct.	Experimental-Dx	35 patients	To determine the use magnetic resonance imaging (MRI) in identifying preoperatively painful vertebrae in patients with multiple-level osteoporotic vertebral compression fractures (VCFs) and to explore the efficacy of selectively performing kyphoplasty (KP) only on painful vertebrae in these patients.	Significant improvements in all efficacy measures were observed at the postoperative versus pre-operative assessments; no significant differences were observed between post-operative and final follow-up assessments.	2
45. Pizones J, Izquierdo E, Alvarez P, et al. Impact of magnetic resonance imaging on decision making for thoracolumbar traumatic fracture diagnosis and treatment. <i>Eur Spine J.</i> 20 Suppl 3:390-6, 2011 Aug.	Review/Other-Dx	30 patients	A prospective study to analyze the usefulness of MRI in fracture diagnosis and its influence on treatment decision making.	30 patients (15 males, 15 females) with an average age of 39.9 years were studied. 41 fractures were initially diagnosed using plain X-rays and CT scans, while MRI diagnosed 50 fractures and 9 vertebral contusions. MRI modified our diagnosis in 40% of our patients (discovering 18 occult injuries), the classification of fracture pattern in 24% of the fractures (mostly upgrading type A to type B patterns) and the therapeutic management in 16% of our patients.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
46. Tsujio T, Nakamura H, Terai H, et al. Characteristic radiographic or magnetic resonance images of fresh osteoporotic vertebral fractures predicting potential risk for nonunion: a prospective multicenter study. <i>Spine (Phila Pa 1976)</i> . 2011; 36(15):1229-1235.	Observational-Dx	350 OVF patients	To identify radiographic or MRIs of fresh vertebral fractures that can predict a high risk for delayed union or nonunion of OVFs.	48 patients (49 vertebrae) among the 350 patients (363 vertebrae) were classified as nonunions, indicating a nonunion incidence of 13.5% for conventional conservative treatments for OVFs. The statistical analyses revealed that a vertebral fracture in the thoracolumbar spine, presence of a middle-column injury, and a confined high intensity or a diffuse low intensity area in the fractured vertebrae on T2-weighted MRIs were significant risk factors for nonunion of OVFs.	2
47. Piazzolla A, Solarino G, Lamartina C, et al. Vertebral Bone Marrow Edema (VBME) in Conservatively Treated Acute Vertebral Compression Fractures (VCFs): Evolution and Clinical Correlations. <i>Spine</i> . 40(14):E842-8, 2015 Jul 15.	Observational-Dx	80 patients; 82 spinal fractures	To assess (1) the evolution of vertebral bone marrow edema (VBME) in patients with A1 vertebral compression fractures (VCFs) conservatively treated and (2) the relationship between VBME and clinical symptoms, evaluated as Visual Analogue Scale (VAS) back pain and Oswestry Disability Index (ODI).	A significant VBME mean area, VAS, and ODI scores reduction was recorded at 60 and 90-days follow-ups versus baseline. A positive correlation between VBME reduction and clinical symptoms improvement (VAS and ODI scores improvement) was found in both traumatic and osteoporotic VCFs.	2
48. Voormolen MH, van Rooij WJ, van der Graaf Y, et al. Bone marrow edema in osteoporotic vertebral compression fractures after percutaneous vertebroplasty and relation with clinical outcome. <i>AJNR Am J Neuroradiol</i> . 27(5):983-8, 2006 May.	Experimental-Dx	64 patients	To prospectively assess the changes in bone marrow edema (BME) with magnetic resonance (MR) imaging at 3, 6, and 12 months after percutaneous vertebroplasty (PV) and related changes in BME with pain evolution and analgesic use over time.	BME gradually decreased over time. At 1 year after PV, 29% of treated vertebral compression fractures (VCF) still demonstrated BME. Once BME disappeared, it did not return. Pain relief was most striking the first 3 months after PV and remained constant thereafter. There was no relation between relief of pain and extent, presence, or absence of BME after PV.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
49. Tang ZB, Lei Z, Yang HL, Chen KW. Value of bone scan imaging in determining painful vertebrae of osteoporotic vertebral compression fractures patients with contraindications to MRI. <i>Orthop Surg.</i> 4(3):172-6, 2012 Aug.	Observational-Dx	23 patients	To assess the value of bone scan imaging in determining painful vertebrae of osteoporotic vertebral compression fractures (OVCFs) patients with contraindications to magnetic resonance imaging (MRI).	The painful vertebrae shown on radiological films did not accord with those found based on bone scan imaging, with a high rate of incongruent findings (27.3%, 9/33). Radiological films showed 33 vertebrae with fractures, but only 26 vertebrae (22 patients) were selected as painful vertebrae for percutaneous kyphoplasty (PKP) based on bone scan imaging. There were statistically significant differences in mean visual analog (VAS) and Oswestry Disability Index (ODI) between the preoperative and the postoperative assessments; no significant differences were observed between postoperative and final follow-up assessments.	3
50. Jordan E, Choe D, Miller T, Chamrathy M, Brook A, Freeman LM. Utility of bone scintigraphy to determine the appropriate vertebral augmentation levels. <i>Clinical Nuclear Medicine.</i> 35(9):687-91, 2010 Sep.	Observational-Dx	44 patients	To assess the ability of preprocedural bone scans to determine the appropriate level(s) of subsequent vertebroplasty.	Our retrospective study assessed the utility of bone scans as a diagnostic tool to identify candidate vertebral levels for vertebroplasty and determined that bone scans were positive in 78.3% of all fractures that subsequently underwent vertebral augmentation procedures. Although no significant difference was seen in the positivity of bone scans to subsequent vertebroplasty levels between benign or metastatic compression fractures (79% vs. 76%), a difference was observed when single level vertebroplasty patients were compared with multiple-level vertebroplasty patients (87% vs. 69%).	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
51. Karam M, Lavelle WF, Cheney R. The role of bone scintigraphy in treatment planning, and predicting pain relief after kyphoplasty. <i>Nuclear Medicine Communications</i> . 29(3):247-53, 2008 Mar.	Observational-Dx	60 patients	To determine the accuracy of bone scanning in patient selection, planning treatment and predicting response to kyphoplasty.	Sixty-six procedures on 60 patients fulfilled the selection criteria. Fifty-three patients were managed by X-ray and bone scanning (A) and seven were managed by X-ray only (B). There was a significant difference in the rates of sub-optimal results between (A) and (B) (11/53 vs. 7/7, P = 0.0001). There was also a significant difference in chronic fracture rates between patients with excellent outcome and those with sub-optimal results (3/42 vs. 7/11, P= 0.0002). A high rate of incorrect level selection (3/7) was found in (B). In 12 patients (20%) X-ray showed multiple fractures but the bone scanning demonstrated only one level of acute disease.	2
52. Lin HH, Chou PH, Wang ST, Yu JK, Chang MC, Liu CL. Determination of the painful level in osteoporotic vertebral fractures--Retrospective comparison between plain film, bone scan, and magnetic resonance imaging. <i>J Chin Med Assoc</i> . 78(12):714-8, 2015 Dec.	Observational-Dx	52 patients	To retrospectively evaluate and compare the findings between plain film, bone scan, and magnetic resonance imaging (MRI) in the diagnosis of new fracture in osteoporotic vertebral fractures.	A total of 52 patients with a mean age of 79.1 years (range 59e92 years) were enrolled in this study, and were treated by vertebroplasty confirmed by MRI. It was observed that patient pain score (visual analog scale) improved from 7.6 to 2.8. Plain film examination revealed 79 vertebrae that were suspected to be compression fractures. Among the suspected vertebrae, 62 showed increased uptake in bone scan, and MRI showed bony edema change in 58 vertebrae. The consistency between bone scan and MRI was 96.9% in patients with single-level suspected fracture on plain film. There was moderate agreement (kappa was 0.56) in patients where multiple levels were noted. Fifteen vertebrae with vacuum cleft sign on plain film showed total concordance in both bone scan and MRI.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
53. Kim JH, Kim JI, Jang BH, Seo JG. The comparison of bone scan and MRI in osteoporotic compression fractures. <i>Asian Spine J.</i> 2010; 4(2):89-95.	Observational-Dx	87 vertebrae in 44 patients	To estimate the usefulness of bone scan and MRI for the diagnosis of new fracture in OVF's.	Hot uptakes in bone scan was matched to 48 new fractures, 26 old fractures and 13 degenerative lesions in MRI findings. It was 55% of concordance between hot uptakes in bone scan and new fractures in MRI. The rate of new vertebral fractures confirmed by MRI according to 1 level hot uptakes in bone scan was 96%, 2 levels was 50% and 3 more levels was 36%.	3
54. Kumar K, Halkar RK, Bartley SC, Schuster DM. Incremental benefit of SPECT + CT bone scans over conventional planar and SPECT bone scans in vertebroplasty. <i>Indian J. Nucl. Med.</i> 26(4):181-4, 2011 Oct.	Review/Other-Dx	20 patients	To review the benefits of Singlephoton emission computed tomography (SPECT) + computed tomography (CT) bone scans over conventional planar and SPECT bone scans in vertebroplasty.	Interpretations changed, on average, 50% of the time as a result of the additional information provided by SPECT+ CT. SPECT + CT more precisely localizes tracer abnormalities in the vertebra compared to SPECT imaging alone	4
55. ap Dafydd D, Salem S, Zerizer I, et al. The value of combined assessment of vertebral fractures with 99mTc MDP scintigraphy and MRI in selecting and planning percutaneous vertebroplasty. <i>Nucl Med Commun.</i> 35(7):755-61, 2014 Jul.	Observational-Dx	39 patients	To establish the degree of concordance between magnetic resonance imaging (MRI) and 99mTc MDP (methyl diphosphonate) scintigraphy in vertebral fracture assessment.	The overall concordance between MRI and 99mTc MDP scintigraphy was 63%. Almost twice as many fractures classified as 'acute/ subacute' on MRI were so classified on 99mTc MDP scintigraphy.	3
56. Sola M, Perez R, Cuadras P, et al. Value of bone SPECT-CT to predict chronic pain relief after percutaneous vertebroplasty in vertebral fractures. <i>Spine Journal: Official Journal of the North American Spine Society.</i> 11(12):1102-7, 2011 Dec.	Experimental-Dx	33 patients	To determine the value of bone single photon emission computed tomography-computed tomography (SPECT-CT) in patient selection, treatment planning, and prediction of response to percutaneous vertebroplasty (PV). A comparison with magnetic resonance imaging (MRI) was also aimed.	Of the 33 patients, 24 finally underwent PV. Positive SPECT-CT images predicted clinical improvement in 91% (21 of 23) of them. Agreement between SPECT-CT and MRI was 80% (20 of 25). Single photon emission computed tomography-computed tomography images showed an alternative cause of pain in some cases, such as new fractures or multiple coexisting fractures, persisting bone remodeling in a previous cemented vertebra, and facet or discal degenerative disease. Single photon emission computed tomography-computed tomography was mandatory in eight patients that could no receive MRI, all of whom improved after PV.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
<p>57. Schmitz A, Risse JH, Textor J, et al. FDG-PET findings of vertebral compression fractures in osteoporosis: preliminary results. <i>Osteoporos Int.</i> 13(9):755-61, 2002 Sep.</p>	<p>Review/Other-Dx</p>	<p>17 patients</p>	<p>To evaluate FDG-PET findings in patients with osteoporosis or preclinical osteoporosis and acute vertebral compression fractures in order to determine whether FDG-PET has a value for distinction of pathological from osteoporotic vertebral fractures</p>	<p>The results of the blinded scoring were compared to MRI findings which served as gold standard. In 13 out of 17 patients, MRI demonstrated a vertebral fracture generating from osteoporosis. In 12 of these 13 cases, PET scans were scored with 0 or 1 and categorized as true negative. Standard uptake values (SUV) ranged between 1.1 and 2.4. In one of the 13 patients, PET was interpreted false positive with an uptake score of 3 (SUV = 2.9). Of the 17 patients, MRI revealed a pathological fracture caused by spondylodiscitis in three patients and by plasmacytoma in one patient. In these patients, all PET scans were highly positive with a score of 3 and 4 and SUV values between 3.8 to 9.8. The bone scans of all 17 patients were positive with scores of 3 or 4 but a differentiation between osteoporotic and pathological fractures was not possible. Our preliminary results indicate that acute vertebral fractures that originated from osteoporosis or preclinical osteoporosis tend to have no pathologically increased FDG uptake. Since a high FDG uptake is characteristic for malignant and inflammatory processes, use of FDG-PET may have potential value for differentiation between osteoporotic and pathological vertebral fractures.</p>	<p>4</p>

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
58. Gratz S, Dorner J, Fischer U, et al. 18F-FDG hybrid PET in patients with suspected spondylitis. <i>Eur J Nucl Med Mol Imaging</i> . 29(4):516-24, 2002 Apr.	Observational-Dx	16 patients	To investigate the value of fluorine-18 2'-deoxy-2-fluoro- D-glucose (FDG) imaging with a double-headed gamma camera operated in coincidence (hybrid PET) detection mode in patients with suspected spondylitis.	Twelve out of 16 patients were found to be positive for spondylitis. Independent of the grade of infection and the location in the spine, all known infected vertebrae (n=23, 9 thoracic, 12 lumbar, 2 sacral) were detected by FDG hybrid PET. T/B ratios higher than 1.45+/-0.05 (at 1 h p.i.) were indicative of infectious disease, whereas ratios below this value were found in cases of degenerative change. FDG hybrid PET was superior to MRI in patients who had a history of surgery and suffered from a high-grade infection in combination with paravertebral abscess formation (n=2; further computed tomography was needed) and in those with low-grade spondylitis (n=2, no oedema) or discitis (n=2, mild oedema). False-positive 67Ga citrate images (n=5: 2 spondylodiscitis, 1 aortitis, 1 pleuritis, 1 pulmonary tuberculosis) and 99mTc-MDP SPET (n=4: 1 osteoporosis, 2 spondylodiscitis, 1 fracture) were equally well detected by FDG hybrid PET and MRI. No diagnostic problems were seen in the other patients (n=5). In this study, FDG hybrid PET was superior to MRI, 67Ga citrate and (99m)Tc-MDP, especially in patients with low-grade spondylitis (as compared with MRI), adjacent soft tissue infections (as compared with 67Ga citrate) and advanced bone degeneration (as compared with 99mTc-MDP).	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
59. De Winter F, Gemmel F, Van De Wiele C, Poffijn B, Uyttendaele D, Dierckx R. 18-Fluorine fluorodeoxyglucose positron emission tomography for the diagnosis of infection in the postoperative spine. <i>Spine</i> . 28(12):1314-9, 2003 Jun 15.	Observational-Dx	57 patients	To investigate the value of 18F-fluorodeoxyglucose positron emission tomography in patients suspected of having spinal infection after previous surgery of the spine.	Fifteen patients had spinal infection. Using the most sensitive cut-off values sensitivity, specificity and accuracy were 100%, 81%, and 86%, respectively, for both visual and semiquantitative scoring. In the group without metallic implants (n = 27), false positives (n = 2) only occurred in the first 6 months after surgery. In the group with metallic implants (n = 30), false positives (n = 6) were not confined to recently operated patients.	1
60. McHenry MC, Duchesneau PM, Keys TF, Rehm SJ, Boumphrey FR. Vertebral osteomyelitis presenting as spinal compression fracture. Six patients with underlying osteoporosis. [Review] [25 refs]. <i>Arch Intern Med</i> . 148(2):417-23, 1988 Feb.	Review/Other-Tx	6 patients	To review the vertebral osteomyelitis in six patients with underlying osteoporosis.	No results stated	4
61. Anselmetti GC, Bernard J, Blatter T, et al. Criteria for the appropriate treatment of osteoporotic vertebral compression fractures. <i>Pain physician</i> . 16(5):E519-30, 2013 Sep-Oct.	Observational-Dx	128 patients	To establish criteria for individually tailored treatment choice in patients with osteoporotic vertebral compression fractures (VCFs), by combining the evidence from clinical studies with the judgment of a multidisciplinary team of experts.	Disagreement dropped from 31% in the first round to 7% in the second round. Appropriateness outcomes showed specific patterns for the 3 treatments. For three-quarters of the profiles, only one treatment was considered appropriate: Non-surgical management (NSM) 25%, vertebroplasty (VP) 6%, and balloon kyphoplasty (BKP) 45%. NSM was usually appropriate in patients with a negative Magnetic Resonance Imaging (MRI) or a positive MRI without other unfavorable conditions (poor outcomes for the other variables). VP was usually appropriate in patients with a positive MRI, time since fracture \geq 6 weeks, and no spinal deformity. BKP was recommended for all patients with an ongoing fracture process, and also in most patients with a positive MRI and \geq 1 other unfavorable factor.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
62. 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. <i>Spine (Phila Pa 1976)</i> . 2009; 34(13):1349-1354.	Experimental-Tx	50 patients	A clinical randomized study to compare PVP to conservative treatment of patients with OVFs in a clinical randomized study with respect to pain, physical and mental outcome, and to assess the risk of adjacent fractures.	There was no significant difference in the other parameters when comparing the results at inclusion and after 3 months within both groups and between the groups after 3 months with a few exceptions. Two adjacent fractures were observed in the PVP group and none in the conservative group. The majority of patients with acute or subacute painful osteoporotic compression fractures in the spine will recover after a few months of conservative treatment. The risk of adjacent fractures needs further research. No major adverse events were observed.	1
63. Kallmes DF, Comstock BA, Heagerty PJ, et al. A randomized trial of vertebroplasty for osteoporotic spinal fractures. <i>N Engl J Med</i> . 2009; 361(6):569-579.	Experimental-Tx	131 patients	A randomized, controlled trial to evaluate the efficacy of PMMA infusion in VP for patients with painful osteoporotic compression fractures, as compared with a simulated procedure without PMMA.	Both groups had immediate improvement in disability and pain scores after the intervention. Although the two groups did not differ significantly on any secondary outcome measure at 1 month, there was a trend toward a higher rate of clinically meaningful improvement in pain (a 30% decrease from baseline) in the VP group (64% vs 48%, P=0.06). At 3 months, there was a higher crossover rate in the control group than in the VP group (43% vs 12%, P<0.001). There was one serious adverse event in each group. Improvements in pain and pain-related disability associated with osteoporotic compression fractures in patients treated with VP were similar to the improvements in a control group.	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
64. Patel U, Skingle S, Campbell GA, Crisp AJ, Boyle IT. Clinical profile of acute vertebral compression fractures in osteoporosis. Br J Rheumatol. 1991; 30(6):418-421.	Review/Other-Dx	30 patients	To provide a clinical profile of acute VCFs in osteoporosis.	The position of comfort was lying flat (43%) or sitting (36%) but 16% found standing or walking most comfortable. The correct diagnosis was made at the first visit in only 43% of patients. In the remainder there was a mean delay of 4.5 days before diagnosis. This poor diagnostic rate may be improved if other clinical features of osteoporosis such as kyphosis and a previous history of wrist and hip fractures are recorded, particularly when acute back pain occurs in bed. Full thoracic and lumbar radiographs may be required because pain and site of pathology may not coincide. Bone scanning may be necessary if immediate radiographs are normal. In early management the position of most comfort may be preferable to complete bed rest.	4
65. Silverman SL. The clinical consequences of vertebral compression fracture. Bone. 1992; 13 Suppl 2:S27-31.	Review/Other-Dx	N/A	To evaluate the clinical consequences of VCF.	Radiographic VCF may not be symptomatic. The greater the deformity, the greater the likelihood of pain and disability. As height is lost, patients experience discomfort from the rib cage pressing downward on the pelvis. Patients develop a thoracic kyphosis, a lumbar lordosis, and a protuberant abdomen with prominent horizontal skinfold creases. The reduced thoracic space may result in decreased exercise tolerance and reduced abdominal space may give rise to early satiety and weight loss. The aims of acute management are to reduce symptoms and mobilize the patient as quickly as possible.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
66. Cortet B, Cotten A, Boutry N, et al. Percutaneous vertebroplasty in the treatment of osteoporotic vertebral compression fractures: an open prospective study. <i>J Rheumatol.</i> 1999; 26(10):2222-2228.	Observational-Tx	16 patients	To assess the efficacy and safety of PVP in osteoporotic VCFs responsible for severe and persistent pain.	A statistically significant decrease of both VAS (-53%, P<0.0005) and McGill-Melzack scoring system (P<0.005) was observed at day 3. The results were also significant at days 30, 90, and 180 for both scales (P<0.005 and P=0.01, respectively). A significant decrease over time for 5/6 dimensions of the Nottingham Health Profile score was also noted: pain (P<0.01), physical mobility (P<0.05), emotional reactions (P<0.05), social isolation (P<0.05), and energy (P<0.05). There was no adverse event observed, and no vertebral fracture has occurred after 6 months of follow-up. PVP is a useful and safe procedure for treating persistent painful osteoporotic fractures. Controlled studies with long-term follow-up are required.	2
67. Cotten A, Boutry N, Cortet B, et al. Percutaneous vertebroplasty: state of the art. <i>Radiographics.</i> 1998; 18(2):311-320; discussion 320-313.	Review/Other-Tx	N/A	To review the principal indications for VP and procedures.	VP is an attractive interventional radiologic procedure that allows rapid pain relief and vertebral consolidation in most cases. However, the success of this technique depends in large part on the quality of the indications, which can only be determined with a multidisciplinary approach. Radiologists, radiation therapists, clinicians, and surgeons should all be aware of the various indications for this technique and of potential future developments.	4
68. Do HM.. Percutaneous vertebroplasty: rationale, clinical outcomes, and future directions. [Review] [80 refs]. <i>Neuroimaging Clin N Am.</i> 13(2):343-63, 2003 May.	Review/Other-Dx	N/A	To discuss the societal significance of osteoporosis; the clinical picture of vertebral body collapse, including patient history, indications for treatment, technique, pitfalls, and clinical outcomes; and research and development in percutaneous vertebroplasty.	No results stated in abstract.	4

Management of Vertebral Compression Fractures
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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
69. 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.	Review/Other-Tx	29 patients	To describe a technique for PVP of osteoporotic VCFs and to report early results of its use.	Two patients sustained single, nondisplaced rib fractures during the procedure; otherwise, no clinically significant complications were noted. Twenty-six patients (90%) reported significant pain relief immediately after treatment. VP is a valuable tool in the treatment of painful OVFs, providing acute pain relief and early mobilization in appropriate patients.	4
70. 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.	Experimental-Tx	78 patients	To determine whether there is evidence to support the use of VP for painful OVFs in a randomized, double-blind trial.	VP did not result in a significant advantage in any measured outcome at any time point. There were significant reductions in overall pain in both study groups at each follow-up assessment. At 3 months, the mean (+/-SD) reductions in the score for pain in the VP and control groups were 2.6+/-2.9 and 1.9+/-3.3, respectively (adjusted between-group difference, 0.6; 95% CI -0.7 to 1.8). Similar improvements were seen in both groups with respect to pain at night and at rest, physical functioning, quality of life, and perceived improvement. 7 incident vertebral fractures (3 in the VP group and 4 in the placebo group) occurred during the 6-month follow-up period. There was no beneficial effect of VP as compared with a sham procedure in patients with painful OVFs, at 1 week or at 1, 3, or 6 months after treatment.	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
71. 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. <i>Lancet</i> . 2010; 376(9746):1085-1092.	Experimental-Tx	431 patients	To clarify whether VP has additional value compared with optimum pain treatment in patients with acute vertebral fractures.	Between Oct 1, 2005, and June 30, 2008, we identified 431 patients who were eligible for randomization. 229 (53%) patients had spontaneous pain relief during assessment, and 202 patients with persistent pain were randomly allocated to treatment (101 VP, 101 conservative treatment). VP resulted in greater pain relief than did conservative treatment; difference in mean VAS score between baseline and 1 month was -5.2 (95% CI, -5.88 to -4.72) after VP and -2.7 (-3.22 to -1.98) after conservative treatment, and between baseline and 1 year was -5.7 (-6.22 to -4.98) after VP and -3.7 (-4.35 to -3.05) after conservative treatment. The difference between groups in reduction of mean VAS score from baseline was 2.6 (95% CI, 1.74-3.37, P<0.0001) at 1 month and 2.0 (1.13-2.80, P<0.0001) at 1 year. No serious complications or adverse events were reported.	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
72. Rousing R, Hansen KL, Andersen MO, Jespersen SM, Thomsen K, Lauritsen JM. Twelve-months follow-up in forty-nine patients with acute/semi-acute osteoporotic vertebral fractures treated conservatively or with percutaneous vertebroplasty: a clinical randomized study. <i>Spine (Phila Pa 1976)</i> . 2010; 35(5):478-482.	Experimental-Tx	50 patients (41 females)	Clinical randomized study in which PVP is compared to conservative treatment in patients with acute or subacute OVs with respect to pain, physical and mental outcomes. The risk of vertebral fractures adjacent to treated levels is assessed.	Pain score before and after the operation in the PVP group was 7.9 and 2.0, respectively. No difference existed between the groups concerning pain at the 3- and 12-months follow-up. Supplementary assessment of back pain one month after discharge from hospital showed a significant lower VAS score in the PVP group over the conservative group. In the study period, two adjacent fractures in the PVP group and no adjacent fractures in the conservative group were registered. PVP is a good treatment for some patients with acute/subacute painful OVs, but the majority of fractures will heal after 8 to 12 weeks of conservative treatment with subsequent decline in pain. Risk of new fractures needs further research.	1
73. 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. <i>Lancet</i> . 2009; 373(9668):1016-1024.	Experimental-Tx	300 patients	To assess the efficacy and safety of balloon KP.	138 participants in the KP group and 128 controls completed follow-up at 1 month. By use of repeated measures mixed effects modeling, all 300 randomized participants were included in the analysis. Mean SF-36 PCS score improved by 7.2 points (95% CI, 5.7-8.8), from 26.0 at baseline to 33.4 at 1 month, in the KP group, and by 2.0 points (0.4-3.6), from 25.5 to 27.4, in the non-surgical group (difference between groups 5.2 points, 2.9-7.4; P<0.0001). The frequency of adverse events did not differ between groups. There were 2 serious adverse events related to KP (haematoma and urinary tract infection); other serious adverse events (such as myocardial infarction and pulmonary embolism) did not occur perioperatively and were not related to procedure.	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
74. Kanayama M, Oha F, Iwata A, Hashimoto T. Does balloon kyphoplasty improve the global spinal alignment in osteoporotic vertebral fracture?. <i>International Orthopaedics</i> . 39(6):1137-43, 2015 Jun.	Observational-Dx	56 patients	To evaluate the effect of balloon kyphoplasty (BKP) on the global spinal alignment in osteoporotic vertebral compression fracture (OVCF).	Fifty-one of 56 patients (91.1 %) achieved immediate pain relief. Vertebral kyphosis significantly decreased from 18 to 14 degrees, but 43 patients (76.8 %) still had more than 10 degrees of local kyphosis. Subsequent vertebral compression fractures were observed in seven patients (12.5 %). Anterior deviation of a C7 plumb line (C7PL) was 3.1 cm pre-operatively, 3.1 cm postoperatively, and significantly increased to 5.9 cm at the final follow-up. Consistent results were obtained in those with pre-operative sagittal imbalance (>5 cm anterior deviation of C7PL) and with pre-existing OVCFs.	2
75. Bouza C, Lopez T, Magro A, Navalpotro L, Amate JM. Efficacy and safety of balloon kyphoplasty in the treatment of vertebral compression fractures: a systematic review. [Review] [60 refs]. <i>Eur Spine J</i> . 15(7):1050-67, 2006 Jul.	Review/Other-Dx	26 studies.	To evaluate the efficacy and safety of balloon kyphoplasty (BK) in the management of vertebral compression fractures (VCFs).	No results stated in abstract.	4
76. Noriega DC, Kruger A, Ramajo RH, Ardura F, Munoz M, Sahin S. Long-Term Benefits of Percutaneous Anatomical Restoration of Vertebral Compression Fractures Linked to Malignancy. <i>Turkish Neurosurgery</i> . 26(4):608-14, 2016.	Observational-Dx	32 patients	To evaluate the efficacy, feasibility and safety of a percutaneous anatomical vertebral body reduction for the treatment of VCF (vertebral compression fracture) linked to malignancy.	Statistically significant reductions in anterior and central vertebral body heights (6.2 mm-19.6 +/- 4.2 mm- and 5.8 mm-16.7 +/- 7.8 mm-, respectively) that resulted in reductions of the regional Cobb angles exceeding 30% were observed. There was also a statistically significant improvement in quality of life. The average survival was longer than those reported in most published articles, and the average follow-up period was 30.9 months.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
77. Yokoyama K, Kawanishi M, Yamada M, et al. In not only vertebroplasty but also kyphoplasty, the resolution of vertebral deformities depends on vertebral mobility. <i>Ajnr: American Journal of Neuroradiology</i> . 34(7):1474-8, 2013 Jul.	Experiment al-Dx	119 patients	To determine whether the balloon inflation in kyphoplasty (KP) may contribute to postoperative resolution of the vertebral deformities in patients with vertebral compression fracture (VCFs).	Overall, no significant differences were observed in either the vertebral height restoration or kyphotic change between the vertebroplasty (VP) and kyphoplasty (KP) groups ($P > .20$). Preoperative dynamic imaging identified 19 vertebral bodies each with vertebral mobility in the VP (56%) and KP groups (44%) ($P = .21$). Within the VP and KP groups, the vertebral height restoration and kyphotic changes were significantly better in patients with vertebral mobility than in those without ($P < .01$). There were no significant differences between the 2 treatment groups after adjustment for the presence of vertebral mobility ($P > .30$).	3
78. Yokoyama K, Kawanishi M, Yamada M, et al. Postoperative change in sagittal balance after Kyphoplasty for the treatment of osteoporotic vertebral compression fracture. <i>European Spine Journal</i> . 24(4):744-9, 2015 Apr.	Experiment al-Dx	32 patients	To analyze the changes in total spinal alignment after Kyphoplasty in vertebral compression fracture (VCF) patients.	In VCF patients, preoperative Sagittal vertical axis (SVA) was 7.00 +/- 3.9 cm, showing a significant shift to anterior sagittal balance as compared to the healthy group (1.45 +/- 2.7 cm) ($P < 0.0001$). Preoperative Sacral slope (SS) was smaller and Pelvic tilt (PT) was larger in Vertebral compression fracture (VCF) group than in the healthy group ($P < 0.05$). After Kyphoplasty, SVA decreased to 5.02 +/- 2.91 ($P = 0.0007$) and Lumbar lordosis (LL) and Spinosacral angle (SSA) increased (LL $P = 0.028$; SSA $P = 0.0031$). Postoperative decrease of SVA was correlated with the kyphotic change of treated vertebra ($r = 0.792$, $P < 0.01$). Visual analog scale (VAS) score decreased from 7.98 +/- 1.8 before Kyphoplasty to 2.38 +/- 2.3 postoperatively ($P < 0.0001$).	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
79. Dong R, Chen L, Gu Y, et al. Improvement in respiratory function after vertebroplasty and kyphoplasty. <i>Int Orthop.</i> 33(6):1689-94, 2009 Dec.	Experimental-Dx	38 women	To study the changes in respiratory function of patients with osteoporotic vertebral compression fractures (OVCFs) after vertebroplasty and kyphoplasty.	Vital capacity, forced vital capacity and maximum voluntary ventilation significantly increased three days after operation ($P < 0.01$), but only maximum voluntary ventilation went on to improve three months later ($P < 0.01$); the thoracic kyphotic angle had a significantly negative correlation with vital capacity (vertebroplasty: $r = -0.832$; kyphoplasty: $r = -0.546$). In thoracic subgroups, the improvement of the local kyphotic angle and vital capacity had a remarkably positive correlation (vertebroplasty: $r = 0.778$; kyphoplasty: $r = 0.637$), and kyphoplasty could improve vital capacity more than vertebroplasty ($P < 0.01$).	2
80. Lee JS, Kim KW, Ha KY. The effect of vertebroplasty on pulmonary function in patients with osteoporotic compression fractures of the thoracic spine. <i>Journal of Spinal Disorders & Techniques.</i> 24(2):E11-5, 2011 Apr.	Experimental-Dx	72 patients	To determine the effect of vertebroplasty on pulmonary function in patients with osteoporotic compression fractures of the thoracic spine.	The preoperative and postoperative (2 d, 1 mo, and 3 mo) PFT parameters were as follows: % predicted forced vital capacity (% pred FVC), 58+/-23.8, 71.8+/-22.2, 75.4+/-21.4, and 76+/-22.1; % predicted forced expiratory volume in 1 s (% pred FEV1), 58.3+/-24.3, 66.1+/-23.7, 67.5+/-24.2, and 68+/-24.5; FEV1/FVC ratio (%), 101.2+/-17.8, 91.3+/-15.5, 88.8+/-15.2, and 88.6+/-14.2, respectively. The preoperative mean VAS score was 7.93+/-1.5 and significantly decreased to 3.15+/-1.59, 1.76+/-1.26, and 1.67+/-1.23 at 2 days, 1 month, and 3 months after the vertebroplasty, respectively. There were no significant differences in the thoracic and local kyphotic angles after the vertebroplasty compared with the preoperative values. The decrease in the visual analogue scale (VAS) scores and age correlated with the Pulmonary function tests (PFTs) parameters; however, there were no significant correlations between the PFT parameters and other variables.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
81. Tanigawa N, Kariya S, Komemushi A, Nakatani M, Yagi R, Sawada S. Added value of percutaneous vertebroplasty: effects on respiratory function. <i>AJR Am J Roentgenol.</i> 2012; 198(1):W51-54.	Observational-Tx	98 patients	To investigate the effects of PVP on respiratory function in patients with compression fractures caused by osteoporosis.	The VC% and FVC% values had improved significantly by 1 month after PVP compared with before PVP ($P < 0.01$). No significant difference was noted between values before and 1 day after PVP. Likewise, no significant difference was identified in %FEV1 before PVP and either 1 day or 1 month after PVP. The mean degree of improvement in VC% values after PVP for patients with one vertebra treated, which we refer to as the “single-VP” group, and for patients with two or more vertebrae treated, or “multiple-VP” group, was 1.1% +/- 7% (SD) and 6.3% +/- 8%, respectively, representing a significant difference between groups ($P = 0.01$). The mean VC% values before and 1 month after PVP differed significantly ($P = 0.02$) in the thoracic group and overlapping group.	2
82. Yang EZ, Xu JG, Huang GZ, et al. Percutaneous Vertebroplasty Versus Conservative Treatment in Aged Patients With Acute Osteoporotic Vertebral Compression Fractures: A Prospective Randomized Controlled Clinical Study. <i>Spine.</i> 41(8):653-60, 2016 Apr.	Experimental-Dx	135 patients.	To determine whether percutaneous vertebroplasty (PVP) offers extra benefits to aged patients with acute osteoporotic vertebral compression fractures (OVCFs) over conservative therapy (CV).	A total of 135 patients were enrolled, and 107 (56 in PVP group; 51 in CV group) completed 1-year follow-up. In PVP group, the vertebroplasty procedure was performed at a mean of 8.4 +/- 4.6 days (range, 2-21 days) after onset. Vertebroplasty resulted in much greater pain relief than did conservative treatment at postoperative day 1 ($P < 0.0001$). At every time point of follow-up, pain relief and quality of life were significantly improved in PVP group than in CV group at 1 week, 1 month, 3 months, 6 months, and 1 year (all $P < 0.0001$). The final follow-up surveys indicated that patients in PVP group were significantly more satisfied with given treatment ($P < 0.0001$). In addition, lower rate of complications was observed in PVP group ($P < 0.0001$).	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
83. Pneumaticos SG, Chatziioannou SN, Savvidou C, Pilichou A, Rontogianni D, Korres DS. Routine needle biopsy during vertebral augmentation procedures. Is it necessary?. <i>European Spine Journal</i> . 19(11):1894-8, 2010 Nov.	Experimental-Dx	75 patients	To determine the frequency of underlying previously unrecognized etiology in a consecutive series of patients undergoing kyphoplasty to treat vertebral compression fractures.	In all but one patient the results of the biopsy confirmed the diagnosis suspected from the preoperative workup. For the last patient, namely the one with pancreatic cancer, the workup did not identify the origin of the primary tumor, although the patient was considered to have a compression fracture secondary to metastatic disease of unknown origin, the vertebral biopsy suggested the presence of adenocarcinoma which eventually was proven to be pancreatic cancer.	3
84. Venturi C, Barbero S, Tappero C, et al. Coaxial biopsy during percutaneous vertebroplasty in patients with presumed osteoporotic vertebral compression fractures: retrospective review of biopsy results. <i>Radiologia Medica</i> . 116(2):302-9, 2011 Mar.	Experimental-Dx	98 patients	To retrospectively analyze the results of biopsies obtained during percutaneous vertebroplasty (PVP) in patients with presumed osteoporotic vertebral compression fractures, with a view to highlighting the importance of coaxial biopsy in determining the aetiology of vertebral fractures and planning subsequent treatment.	In 83 patients, the biopsy results were consistent with the presumed osteoporotic aetiology. In two patients, a malignancy was identified. Biopsy samples from 13 patients were considered insufficient or unsuitable by them pathologist for evaluation.	3
85. Muijs SP, Akkermans PA, van Erkel AR, Dijkstra SD. The value of routinely performing a bone biopsy during percutaneous vertebroplasty in treatment of osteoporotic vertebral compression fractures. <i>Spine</i> . 34(22):2395-9, 2009 Oct 15.	Experimental-Dx	78 patients	To determine the rate of unsuspected malignancy in bone biopsies of patients undergoing percutaneous vertebroplasty (PVP) for osteoporotic vertebral compression fractures.	Seventy-one biopsies (91%) obtained from 71 patients, were suitable for histologic evaluation. Seven biopsies (9.0%) could not be interpreted as a result of suboptimal quality biopsy material. The population included 10 patients (13%) with a history of malignancy, in this group no malignancy was found in the bone biopsies. In 3 patients (3.8% of all biopsies) previously undiagnosed malignancies, 2 multiple myeloma stage IIa and 1 chondrosarcoma grade I, were found.	3
86. Georgy BA.. Metastatic spinal lesions: state-of-the-art treatment options and future trends. [Review] [40 refs]. <i>AJNR Am J Neuroradiol</i> . 29(9):1605-11, 2008 Oct.	Review/Other-Dx	N/A	To review the current state of the art for treating symptomatic spinal fractures associated with malignant lesions and to present potential future trends in treatments for this patient population.	No results stated in abstract.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
87. Ploeg WT, Veldhuizen AG, The B, Sietsma MS. Percutaneous vertebroplasty as a treatment for osteoporotic vertebral compression fractures: a systematic review. [Review] [56 refs]. Eur Spine J. 15(12):1749-58, 2006 Dec.	Review/Other-Dx	15 articles	To review percutaneous vertebroplasty as a treatment for osteoporotic vertebral compression fractures.	No results stated in abstract.	4
88. 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.	Observational-Tx	34 patients	To prospectively assess the short-term clinical outcome of patients with subacute or chronic painful osteoporotic VCF treated with PVP compared with optimal pain medication.	18 patients treated with PVP compared with 16 patients treated with optimal pain medication had significantly better VAS and used less analgesics 1 day after treatment. 2 weeks after treatment, the mean VAS was less but not significantly different in patients treated with optimal pain medication, whereas these patients used significantly less analgesics and had better Quality of Life Questionnaire of the European Foundation for Osteoporosis and Roland-Morris Disability scores. Scores in the PVP arm were influenced by occurrence of new VCF in 2 patients. After 2 weeks optimal pain medication, 14 patients requested PVP treatment. All scores, 1 day and 2 weeks after PVP, were significantly better compared with scores during conservative treatment.	1
89. Babayev M, Lachmann E, Nagler W. The controversy surrounding sacral insufficiency fractures: to ambulate or not to ambulate?. [Review] [59 refs]. Am J Phys Med Rehabil. 79(4):404-9, 2000 Jul-Aug.	Review/Other-Dx	N/A	To review the controversy of sacral insufficiency fractures.	No results stated in abstract.	4
90. Dittmer DK, Teasell R. Complications of immobilization and bed rest. Part 1: Musculoskeletal and cardiovascular complications. [Review] [48 refs]. Can Fam Physician. 39:1428-32, 1435-7, 1993 Jun.	Review/Other-Dx	N/A	To review the complications of immobilization and bed rest.	No results stated in abstract.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
91. Masala S, Magrini A, Taglieri A, et al. Chronic obstructive pulmonary disease (COPD) patients with osteoporotic vertebral compression fractures (OVCFs): improvement of pulmonary function after percutaneous vertebroplasty (VTP). <i>European Radiology</i> . 24(7):1577-85, 2014 Jul.	Observational-Dx	30 patients	To delineate the utility and the importance of the two diagnostic imaging techniques in the pre-procedural assessment of differently aged vertebral fractures in order to clarify and standardize the international guidelines in pre-operative patient evaluation and management.	In patients, selected after evaluation with magnetic resonance imaging (MRI) and bone scan imaging, both procedures demonstrated swift pain relief associated with vertebral resistance augmentation.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
92. Otten LA, Bornemmn R, Jansen TR, et al. Comparison of balloon kyphoplasty with the new Kiva VCF system for the treatment of vertebral compression fractures. <i>Pain Physician</i> . 16(5):E505-12, 2013 Sep-Oct.	Observational-Dx	52 patients	To evaluate the safety and effectiveness of the Kiva System in comparison to balloon kyphoplasty on the basis of matched pairs.	Mean Visual Analog Scale (VAS) values in both groups improved from preoperatively 87.6 ± 12.8 and 83.1 ± 14.9 to 10.8 ± 20.8 and 24.6 ± 11.0 6 months after the treatment. The improvement after 6 months in the Kiva group was significantly better than in the balloon kyphoplasty group ($P < 0.0001$). Mean Oswestry Disability Index (ODI) scores in both groups also improved from $68.7\% \pm 15.8\%$ in the Kiva group and $80.6\% \pm 8.6\%$ in the balloon kyphoplasty group preoperatively to $24.8 \pm 18.6\%$ and $33.2 \pm 6.3\%$ 6 months after treatment. The mean operation time for the Kiva group was 12.7 ± 3.7 minutes per vertebra and cement leakage occurred in 6 patients. The mean operation time for the balloon kyphoplasty group was 34.1 ± 7.0 minutes per vertebra and cement leakage occurred in 8 patients. Anterior and mid vertebral height in the Kiva group increased from preoperatively 21.06 ± 7.44 mm and 18.36 ± 5.64 mm to postoperatively 22.41 ± 7.14 mm and 20.41 ± 6.00 mm. Anterior and mid vertebral height in the balloon kyphoplasty group increased from preoperatively 21.68 ± 2.06 mm and 21.97 ± 1.78 mm to postoperatively 25.09 ± 2.54 mm and 25.29 ± 2.10 mm. Vertebral height restoration could be therefore maintained with both procedures for 6 months. In the Kiva group 2 cases of nonadjacent fractures and one case of adjacent fractures were observed. In the balloon kyphoplasty group 9 cases of adjacent, as well as 5 cases of nonadjacent, fractures were observed. In the Kiva group significant fewer fractures occurred.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
93. Kim JM, Losina E, Bono CM, et al. Clinical outcome of metastatic spinal cord compression treated with surgical excision +/- radiation versus radiation therapy alone: a systematic review of literature. [Review]. <i>Spine</i> . 37(1):78-84, 2012 Jan 01.	Review/Other-Dx	33 studies	To report the results of a systematic review comparing surgical decompression +/- radiation to radiation therapy alone among patients with metastatic spinal cord compression.	No results stated in abstract.	4
94. Wallace AN, Robinson CG, Meyer J, et al. The Metastatic Spine Disease Multidisciplinary Working Group Algorithms. <i>Oncologist</i> . 20(10):1205-15, 2015 Oct.	Review/Other-Dx	N/A	To document the details about the evidence supporting the Working Group algorithms and include illustrative cases to demonstrate how the algorithms may be applied.	No results stated in abstract.	4
95. Lopez-Olivo MA, Shah NA, Pratt G, Risser JM, Symanski E, Suarez-Almazor ME. Bisphosphonates in the treatment of patients with lung cancer and metastatic bone disease: a systematic review and meta-analysis. [Review]. <i>Support Care Cancer</i> . 20(11):2985-98, 2012 Nov.	Meta-analysis	12 studies; 1,767 participants	To assess the efficacy of bisphosphonates in preventing skeletal-related events (SREs), controlling pain, and overall survival in patients with bone metastases from lung cancer.	Twelve trials met our inclusion criteria and included 1,767 patients. Studies were placebo-controlled, or had compared bisphosphonates with other modalities (chemotherapy, radiation therapy, or radioisotope therapy), or had used different bisphosphonates as active controls. Randomized controlled trials did not report adequate descriptions of randomization procedures, allocation concealment, and blinding, resulting in low-quality scores. Patients treated with zoledronic acid + chemotherapy had fewer SREs than those receiving chemotherapy alone (relative risk (RR) 0.81, 95 % confidence interval (CI) 0.67-0.97). Pain control improved when a bisphosphonate was added to another treatment modality (chemotherapy or radiation; RR 1.18, 95 % CI 1.0-1.4). Bisphosphonate therapy improved survival compared to controls, but the difference failed to reach statistical significance (mean of 72 days, 95 % CI -8.9 to 152.9).	Not Assessed

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
96. Wong MH, Stockler MR, Pavlakis N. Bisphosphonates and other bone agents for breast cancer. [Review][Update of Cochrane Database Syst Rev. 2005;(3):CD003474; PMID: 16034900]. Cochrane Database Syst Rev. (2)CD003474, 2012 Feb 15.	Review/Other-Tx	34 RCTs	To assess the effect of bisphosphonates on skeletal-related events (SREs), bone pain, quality of life (QoL), recurrence and survival in women with breast cancer with bone metastases (BCBM), advanced breast cancer (ABC) without clinical evidence of bone metastases and early breast cancer (EBC) and to assess the effect of denosumab on SREs, bone pain and (QoL) in women with (BCBM).	In nine studies (2806 patients with BCBM), comparing bisphosphonates with placebo or no bisphosphonates, bisphosphonates reduced the SRE risk by 15% (risk ratio (RR) 0.85; 95% confidence interval (CI) 0.77 to 0.94; P = 0.001). This benefit was most certain with intravenous (i.v.) zoledronic acid (4 mg) (RR 0.59; 95% CI 0.42 to 0.82); i.v. pamidronate (90 mg) (RR 0.77; 95% CI 0.69 to 0.87); and i.v. ibandronate (RR 0.80; 95% CI 0.67 to 0.96). A direct comparison of i.v. zoledronic acid and i.v. pamidronate confirmed at least equivalent efficacy in a single large study. In three studies (3405 patients with BCBM), compared with bisphosphonates, subcutaneous (s.c.) denosumab was more effective in reducing the risk of SREs (RR 0.78; 95% CI 0.72 to 0.85; P < 0.00001). Bisphosphonates reduced the SRE rate in 12 studies (median reduction 28%, range 14% to 48%), with statistically significant reductions reported in 10 studies. Women with BCBM treated with bisphosphonates showed significant delays in the median time to SREs. Compared with placebo or no bisphosphonates, treatment with bisphosphonates significantly improved bone pain in six out of eleven studies. Improvements in global QoL with bisphosphonates compared to placebo were reported in two out of five studies (both ibandronate studies). Treatment with bisphosphonates did not appear to affect survival in women with BCBM. Compared to i.v. zoledronic acid, denosumab also significantly reduced the SRE rate, delayed the time to SREs and prolonged the time in developing pain for patients with no or mild pain at baseline; but there was no	4

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				<p>difference in survival between patients treated with denosumab and zoledronic acid. Bisphosphonates in women with ABC without clinically evident bone metastases did not reduce the incidence of bone metastases, or improve survival in three studies (320 patients). In seven studies (7847 patients with EBC), currently there is no evidence supporting bisphosphonates in reducing the incidence of bone metastases compared to no bisphosphonates (RR 0.94; 95% CI 0.82 to 1.07; P = 0.36). In three studies (2190 patients with EBC), early bisphosphonate treatment also did not significantly reduce the incidence of bone metastases compared to delayed bisphosphonate treatment (RR 0.73; 95% CI 0.40 to 1.33; P = 0.31).</p>	

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
<p>97. Yuen KK, Shelley M, Sze WM, Wilt T, Mason MD. Bisphosphonates for advanced prostate cancer. [Review] [51 refs]. Cochrane Database Syst Rev. (4)CD006250, 2006 Oct 18.</p>	<p>Meta-analysis</p>	<p>10 studies; 1955 patients</p>	<p>To determine the effectiveness of bisphosphonates in relieving pain in patients with bone metastases from prostate cancer.</p>	<p>One thousand nine hundred and fifty-five patients from ten studies were included in this review. The pain response rates were 27.9% and 21.1% for the treatment group and the control group, respectively, with an absolute risk difference of 6.8%. The OR for pain response was 1.54 (95% CI 0.97 to 2.44, P = 0.07), showing a trend of improved pain relief in the bisphosphonate group, although this was not statistically significant. The rates for skeletal events were 37.8% and 43.0% for the treatment group and the control group, respectively, with an absolute risk difference of 5.2%. The OR for skeletal events was 0.79 (95% CI 0.62 to 1.00, P = 0.05). A significant increase in nausea was observed in patients who received bisphosphonates compared to placebo. No increase in other adverse events was observed. There was no statistically significant difference between the bisphosphonate group and the control group in terms of prostate cancer death, disease progression, radiological response and PSA response. There are insufficient data to guide the choice of bisphosphonates or the dose and the route of administration.</p>	<p>Not Assessed</p>

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
98. Fizazi K, Carducci M, Smith M, et al. Denosumab versus zoledronic acid for treatment of bone metastases in men with castration-resistant prostate cancer: a randomised, double-blind study. <i>Lancet</i> . 377(9768):813-22, 2011 Mar 05.	Experiment al-Dx	1904 patients	To compare denosumab, a human monoclonal antibody against receptor activator of nuclear factor kappa- B ligand (RANKL), with zoledronic acid for prevention of skeletal-related events in men with bone metastases from castration-resistant prostate cancer.	1904 patients were randomised, of whom 950 assigned to denosumab and 951 assigned to receive zoledronic acid were eligible for the efficacy analysis. Median duration on study at primary analysis cutoff date was 12.2 months (interquartile range (IQR) 5.9-18.5) for patients on denosumab and 11.2 months (IQR 5.6-17.4) for those on zoledronic acid. Median time to first on-study skeletal-related event was 20.7 months (95% CI 18.8-24.9) with denosumab compared with 17.1 months (15.0-19.4) with zoledronic acid (hazard ratio 0.82, 95% CI 0.71-0.95; p = 0.0002 for non-inferiority; p = 0.008 for superiority). Adverse events were recorded in 916 patients (97%) on denosumab and 918 patients (97%) on zoledronic acid, and serious adverse events were recorded in 594 patients (63%) on denosumab and 568 patients (60%) on zoledronic acid. More events of hypocalcaemia occurred in the denosumab group (121 [13%]) than in the zoledronic acid group (55 [6%]; p<0.0001). Osteonecrosis of the jaw occurred infrequently (22 [2%] vs 12 [1%]; p = 0.09).	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
99. Henry DH, Costa L, Goldwasser F, et al. Randomized, double-blind study of denosumab versus zoledronic acid in the treatment of bone metastases in patients with advanced cancer (excluding breast and prostate cancer) or multiple myeloma. <i>J Clin Oncol.</i> 29(9):1125-32, 2011 Mar 20.	Experiment al-Dx	1690 patients	To compare denosumab, a fully human monoclonal anti-receptor activator of nuclear factor kappa-B ligand antibody, with zoledronic acid (ZA) for delaying or preventing skeletal-related events (SRE) in patients with advanced cancer and bone metastases (excluding breast and prostate) or myeloma.	Denosumab was noninferior to ZA in delaying time to first on-study SRE (hazard ratio, 0.84; 95% CI, 0.71 to 0.98; P = .0007). Although directionally favorable, denosumab was not statistically superior to ZA in delaying time to first on-study SRE (P = .03 unadjusted; P = .06 adjusted for multiplicity) or time to first-and-subsequent (multiple) SRE (rate ratio, 0.90; 95% CI, 0.77 to 1.04; P = .14). Overall survival and disease progression were similar between groups. Hypocalcemia occurred more frequently with denosumab. Osteonecrosis of the jaw occurred at similarly low rates in both groups. Acute-phase reactions after the first dose occurred more frequently with ZA, as did renal adverse events and elevations in serum creatinine based on National Cancer Institute Common Toxicity Criteria for Adverse Events grading.	1
100. Stopeck AT, Lipton A, Body JJ, et al. Denosumab compared with zoledronic acid for the treatment of bone metastases in patients with advanced breast cancer: a randomized, double-blind study. <i>J Clin Oncol.</i> 28(35):5132-9, 2010 Dec 10.	Experiment al-Dx	2046 patients	To compare denosumab, a fully human monoclonal antibody against receptor activator of nuclear factor kappa B (RANK) ligand, with zoledronic acid in delaying or preventing skeletal-related events (SREs) in patients with breast cancer with bone metastases.	Denosumab was superior to zoledronic acid in delaying time to first on-study SRE (hazard ratio, 0.82; 95% CI, 0.71 to 0.95; P = .01 superiority) and time to first and subsequent (multiple) on-study SREs (rate ratio, 0.77; 95% CI, 0.66 to 0.89; P = .001). Reduction in bone turnover markers was greater with denosumab. Overall survival, disease progression, and rates of adverse events (AEs) and serious AEs were similar between groups. An excess of renal AEs and acute-phase reactions occurred with zoledronic acid; hypocalcemia occurred more frequently with denosumab. Osteonecrosis of the jaw occurred infrequently (2.0%, denosumab; 1.4%, zoledronic acid; P = .39).	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
101. Abdel-Wanis ME, Solyman MT, Hasan NM. Sensitivity, specificity and accuracy of magnetic resonance imaging for differentiating vertebral compression fractures caused by malignancy, osteoporosis, and infections. <i>J Orthop Surg (Hong Kong)</i> . 2011; 19(2):145-150.	Observational-Dx	80 patients	To evaluate the sensitivity, specificity and accuracy of various MRI features in differentiating VCFs caused by malignancy, osteoporosis, and infections.	The MRI diagnosis was correct in 78 and inconclusive in 2 with malignancy. MRI features suggestive of malignant fractures were a convex posterior border of the vertebral body, pedicle involvement, posterior neural element involvement, an epidural mass, a paraspinal mass, and other spinal metastases. MRI features suggestive of osteoporotic fractures were retropulsion, low signal intensity band, spared normal marrow signal intensity, and the fluid sign. MRI features suggestive of infective fractures were contiguous vertebral involvement, end plate disruption, disc involvement, and paraspinal and epidural abscesses.	3
102. Sung JK, Jee WH, Jung JY, et al. Differentiation of acute osteoporotic and malignant compression fractures of the spine: use of additive qualitative and quantitative axial diffusion-weighted MR imaging to conventional MR imaging at 3.0 T. <i>Radiology</i> . 271(2):488-98, 2014 May.	Observational-Dx	62 patients	To retrospectively determine the value of adding qualitative and quantitative axial diffusion-weighted (DW) imaging to standard spine magnetic resonance (MR) imaging to differentiate between acute osteoporotic and malignant compression fractures at 3.0 Tesla (T).	There were 30 malignant and 32 acute osteoporotic compression fractures. At qualitative analysis, hyperintensity relative to spinal cord was more frequent in malignant compression fractures than in acute osteoporotic compression fractures (87% vs 22%, respectively; P, .001). Median Apparent diffusion coefficients (ADCs) of malignant fractures were significantly lower than those of benign fractures (P, .001). With conventional MR imaging alone, sensitivity, specificity, and accuracy were 100%, 94%, and 97%, respectively, for reader 1; 97%, 78%, and 87% for reader 2; and 100%, 84%, and 92% for reader 3. With conventional and DW MR imaging combined, sensitivity, specificity, and accuracy were 100%, 97%, and 98% for all three readers. The addition of DW imaging led to correct changes in diagnosis: Reader 1 improved by 1.6% (one of 62 fractures), reader 2 improved by 11% (seven of 62 fractures), and reader 3 improved by 6.5% (four of 62 fractures).	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
103. Takigawa T, Tanaka M, Sugimoto Y, Tetsunaga T, Nishida K, Ozaki T. Discrimination between Malignant and Benign Vertebral Fractures Using Magnetic Resonance Imaging. <i>Asian spine j.</i> 11(3):478-483, 2017 Jun.	Observational-Dx	106 patients	To identify magnetic resonance imaging (MRI) features that could discriminate benign from malignant vertebral fractures.	The chi-square test revealed 11 malignant and 4 benign parameters. Multivariate logistic regression analysis selected (i) posterior wall diffuse protrusion (odds ratio [OR], 48; 95% confidence interval [CI], 4.2–548; p =0.002), (ii) pedicle involvement (OR, 21; 95% CI, 2.0–229; p =0.01), (iii) posterior involvement (OR, 21; 95% CI, 1.5–21; p =0.02), and (iv) band pattern (OR, 0.047; 95% CI, 0.0005–4.7; p =0.19). The logit model was expressed as $P=1/[1+\exp(x)]$, $x=-3.88 \times (i) - 3.05 \times (ii) - 3.02 \times (iii) + 3.05 \times (iv) + 5.00$, where P is the probability of malignancy. The total predictive value was 97.3%. The only exception was multiple myeloma with features of a benign fracture.	3
104. Torres C, Hammond I. Computed Tomography and Magnetic Resonance Imaging in the Differentiation of Osteoporotic Fractures From Neoplastic Metastatic Fractures. <i>J Clin Densitom.</i> 19(1):63-9, 2016 Jan-Mar.	Review/Other-Dx	N/A	To determine the use of computed tomography (CT) and magnetic resonance (MR) in the differentiation of fractures due to osteoporosis (OP) from those due to metastatic disease.	No results stated in abstract.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
105. Kroon HM, Bloem JL, Holscher HC, van der Woude HJ, Reijnierse M, Taminiau AH. MR imaging of edema accompanying benign and malignant bone tumors. <i>Skeletal Radiol</i> 1994;23:261-9.	Review/Other-Dx	63 patients	To evaluate the incidence, quantity, and presentation of intra- and extraosseous edema accompanying benign and malignant primary bone lesions, the magnetic resonance (MR) studies of 63 consecutive patients with histologically proven primary bone tumors were reviewed. MR scans were assessed for the presence and quantity of marrow and soft tissue edema and correlated with peroperative findings, resected specimens and follow-up data.	In 36 patients the contrast medium Gd-DTPA was used. Edema was present in 27 of these patients and the respective enhancement of tumor and edema could be compared. Edema always enhanced homogeneously, and in most cases it enhanced to a similar degree as or more than tumor. Marrow and, more specifically, soft tissue edema is a frequent finding adjacent to primary bone tumors. The mere presence and quantity of marrow and soft tissue edema are unreliable indicators of the biologic potential of a lesion. Unenhanced MR scans cannot always differentiate between tumor and edema, but the administration of Gd-DTPA is of assistance in differentiating tumor from edema.	4
106. Biffar A, Sourbron S, Dietrich O, et al. Combined diffusion-weighted and dynamic contrast-enhanced imaging of patients with acute osteoporotic vertebral fractures. [Erratum appears in <i>Eur J Radiol</i> . 2011 Mar;77(3):528]. <i>Eur J Radiol</i> . 76(3):298-303, 2010 Dec.	Observational-Dx	20 patients	To evaluate the potential and to analyze parameter correlations of combined quantitative diffusion-weighted magnetic resonance imaging (DWI) and high-temporal-resolution dynamic contrast-enhanced MRI (DCEMRI) in vertebral bone marrow (vBM) of patients with osteoporosis and acute vertebral compression fractures, providing additional information for a better understanding of the physiological background of parameter changes.	Mean perfusion parameters and apparent diffusion coefficient's (ADC's) were significantly ($p < 0.001$) different in the fractures compared to adjacent normal appearing vertebrae (Ktrans: 7.81 mL/100 mL/min vs. 14.61 mL/100 mL/min, extracellular volume (ECV): 52.84 mL/100mL vs. 4.61 mL/100 mL, ADC: $1.71 \times 10^{-3} \text{mm}^2/\text{s}$ vs. $0.57 \times 10^{-3} \text{mm}^2/\text{s}$). ADCs showed a significant correlation with the ECV.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
<p>107. Chiewvit P, Danchaivijitr N, Sirivitmaitrie K, Chiewvit S, Thephamongkhol K. Does magnetic resonance imaging give value-added than bone scintigraphy in the detection of vertebral metastasis?. J Med Assoc Thai. 92(6):818-29, 2009 Jun.</p>	<p>Observational-Dx</p>	<p>48 patients</p>	<p>To determine the role of Magnetic Resonance (MR) imaging for the investigation of patients with suspected metastasis to the spine by bone scintigraphy.</p>	<p>Forty-eight cases (80 lesions) of vertebral metastasis were identified (25 men and 23 women; mean age 61 years and range 8-84 years). Primary neoplasms include breast cancer (n=11), colorectal cancer (n=7), lung cancer (n=6), prostate cancer (n=5), nasopharyngeal cancer (n=5), head and neck cancer (n=3), thyroid cancer (n=2), liver cancer (n=2), esophagus cancer (n=1), bladder cancer (n=1), retroperitoneum cancer (n=1), medulloblastoma (n=1), cervical cancer (n=1), ovarian cancer (n=1), malignant melanoma (n=1). The result of bone scintigraphy and MR imaging is used to evaluate vertebral metastasis: in 44 lesions of bone scintigraphy positive for vertebral metastasis, 40/44 lesions (91%) which MR imaging reveal vertebral metastasis. This group may not benefit for further investigation by MR imaging. In 24 lesions of negative of bone scintigraphy for vertebral metastasis, the authors found that 14/24 lesions (58%) showed positive of vertebral metastasis from MR imaging. In this group, the authors recommended a further investigation because 58% of negative bone scintigraphy lesions are depicted by only MR imaging. MR imaging demonstrated metastatic cord compression in 16 cases. Extradural extension causes spinal canal narrowing in 30 cases.</p>	<p>3</p>

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
108. Wallace AN, Greenwood TJ, Jennings JW. Use of Imaging in the Management of Metastatic Spine Disease With Percutaneous Ablation and Vertebral Augmentation. [Review]. AJR Am J Roentgenol. 205(2):434-41, 2015 Aug.	Review/Other-Dx	N/A	To describe the role of imaging in the management of metastatic spine disease with percutaneous ablation and vertebral augmentation.	No results stated in abstract.	4
109. Jabbari S, Gerszten PC, Ruschin M, Larson DA, Lo SS, Sahgal A. Stereotactic Body Radiotherapy for Spinal Metastases: Practice Guidelines, Outcomes, and Risks. [Review]. Cancer J. 22(4):280-9, 2016 Jul-Aug.	Review/Other-Tx	N/A	To review the highlights the current state of the evidence, understanding of the late effects, and technological requirements for spine stereotactic body radiotherapy specific to spinal metastases.	No results stated in the abstract	4
110. Sahgal A, Atenafu EG, Chao S, et al. Vertebral compression fracture after spine stereotactic body radiotherapy: a multi-institutional analysis with a focus on radiation dose and the spinal instability neoplastic score. Journal of Clinical Oncology. 31(27):3426-31, 2013 Sep 20.	Review/Other-Dx	N/A	To summarise the evidence and predictive factors for Vertebral compression fracture (VCF) induced by spinal stereotactic body radiotherapy (SBRT), review the pathophysiology of VCF in the metastatic spine, and discuss strategies used to prevent and manage this potentially disabling complication.	No results stated in abstract.	4
111. Gosfield E 3rd, Alavi A, Kneeland B. Comparison of radionuclide bone scans and magnetic resonance imaging in detecting spinal metastases. J Nucl Med. 34(12):2191-8, 1993 Dec.	Observational-Dx	35 patients	To determine the complementary role of magnetic resonance (MR) imaging to that of bone scintigraphy in the work-up of patients with suspected metastases to the spine.	Of the regions compared, 69 were positive for bony metastases by MRI and 63 regions by bone scans. Thirty-eight regions were concordantly positive and 56 regions concordantly negative. No patients with entirely positive bone scans were negative by MRI, but one patient was entirely positive by MRI but negative by a bone scan. At least one region was discordantly read in 21 patients. Distribution of positive regions was similar on bone scan and MRI. The greatest number and proportion of discordant readings occurred in the lumbar regions and more frequently in patients with prostate cancer.	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
112. Venkitaraman R, Cook GJ, Dearnaley DP, et al. Does magnetic resonance imaging of the spine have a role in the staging of prostate cancer?. Clin Oncol (R Coll Radiol). 21(1):39-42, 2009 Feb.	Observational-Dx	99 patients	To compare magnetic resonance imaging (MRI) spine with radionuclide bone scan in detecting spinal metastases for staging prostate cancer patients.	Ten patients were detected to have definite spinal metastasis by bone scan, whereas 12 patients had definite skeletal metastasis by MRI spine. Compared with the 'gold standard', derived from clinical and radiological follow-up, the sensitivities for radionuclide bone scan and that for MRI spine for detecting skeletal metastasis were 71.4 and 85.7%, respectively (P[0.023]), whereas the specificities were 96.5 and 97.7%, respectively (P[0.95]). Of the 34 individual metastatic lesions in the spine, 15 were concordantly positive on both scans, whereas five lesions were positive only by bone scan and 11 positive only by MRI. The addition of MRI spine in the staging for prostate cancer resulted in a change of stage and management plan in seven (7%) patients.	3
113. Alexandru D, So W. Evaluation and management of vertebral compression fractures. [Review]. Permanente Journal. 16(4):46-51, 2012Fall.	Review/Other-Tx	N/A	To review the pathogenesis and pathophysiology of compression fractures, as well as clinical manifestations and treatment options.	No results stated in the abstract.	4
114. Beheshti M, Rezaee A, Geinitz H, Loidl W, Pirich C, Langsteger W. Evaluation of Prostate Cancer Bone Metastases with 18F-NaF and 18F-Fluorocholine PET/CT. J Nucl Med. 2016;57(Suppl 3):55S-60S.	Review/Other-Dx	N/A	To evaluate the value of 18F-NaF PET/CT and 18F-fluorocholine PET/CT in the assessment of bone metastases in prostate cancer.	No results were stated in the abstract	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
<p>115. Lee CH, Chung CK, Jahng TA, et al. Which one is a valuable surrogate for predicting survival between Tomita and Tokuhashi scores in patients with spinal metastases? A meta-analysis for diagnostic test accuracy and individual participant data analysis. J Neurooncol. 123(2):267-75, 2015 Jun.</p>	<p>Meta-analysis</p>	<p>22 studies</p>	<p>To estimate the diagnostic accuracy of Tokuhashi and Tomita scores that assures 6-month predicting survival regarded as a standard of surgical treatment.</p>	<p>In the meta-analysis, the pooled sensitivity/specificity/DOR for 6-month survival were 57.7 %/ 76.6 %/4.70 for the Tokuhashi score and 81.8 %/47.8 %/ 4.93 for Tomita score. The AUC of summary receiver operating characteristic plots was 0.748 for the Tokuhashi score and 0.714 for the Tomita score. Although Tokuhashi score was more accurate than Tomita score slightly, both showed low accuracy to predict 6 months residual survival. Moreover, the best cut-off values of Tokuhashi and Tomita scores were 8 and 6, not 9 and 7, for predicting 6-month survival, respectively.</p>	<p>Good</p>

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
116. 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. <i>Lancet Oncol.</i> 2011; 12(3):225-235.	Experimental-Tx	134 patients	To assess the efficacy and safety of balloon KP compared with non-surgical management for patients with cancer who have painful VCFs.	Between May 16, 2005, and March 11, 2008, 134 patients were enrolled and randomly assigned to KP (n=70) or non-surgical management (n=64). 65 patients in the KP group and 52 in the control group had data available at 1 month. The mean Roland-Morris disability questionnaire score in the KP group changed from 17.6 at baseline to 9.1 at 1 month (mean change -8.3 points, 95% CI, -6.4 to -10.2; P<0.0001). The mean score in the control group changed from 18.2 to 18.0 (mean change 0.1 points; 95% CI, -0.8 to 1.0; P=0.83). At 1 month, the KP treatment effect for Roland-Morris disability questionnaire was -8.4 points (95% CI, -7.6 to -9.2; P<0.0001). The most common adverse events within the first month were back pain (4/70 in the KP group and 5/64 in the control group) and symptomatic vertebral fracture (two and three, respectively). One patient in the KP group had an intraoperative non-Q-wave myocardial infarction, which resolved and was attributed to anesthesia. Another patient in this group had a new VCF, which was thought to be device related.	1
117. 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. <i>Radiology.</i> 200(2):525-30, 1996 Aug.	Experimental-Dx	37 patients	To determine whether the percentage of vertebral lesion filling and the leakage of methyl methacrylate have any clinical significance at follow-up.	Partial or complete pain relief was sustained in 36 of 37 patients Pain relief was not proportional to the percentage of lesion filling. Clinical improvement was maintained in most patients. The 15 epidural leaks, eight intradiskal leaks, and two venous leaks of methyl methacrylate had no clinical importance. Two of eight foraminal leaks produced nerve root compression that required decompressive surgery. One of 21 paravertebral leaks produced transitory femoral neuropathy.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
118. Chow E, Zeng L, Salvo N, Dennis K, Tsao M, Lutz S. Update on the systematic review of palliative radiotherapy trials for bone metastases. [Review]. Clin Oncol (R Coll Radiol). 24(2):112-24, 2012 Mar.	Meta-analysis	25 randomised trials	To update previous meta-analyses of randomised palliative radiotherapy trials comparing single fractions versus multiple fractions.	In total, 25 randomised controlled trials were identified. For intention-to-treat patients, the overall response rate was similar in patients receiving single fractions (1696 of 2818; 60%) and multiple fractions (1711 of 2799; 61%). Complete response rates were 620 of 2641 (23%) in the single fraction arm and 634 of 2622 (24%) in the multiple fraction arm. No significant difference was seen in overall or complete response rates. Pathological fracture did not favour either arm, but spinal cord compression trended towards favouring multiple fractions; however, neither was statistically significant (P $\frac{1}{4}$ 0.72 and P $\frac{1}{4}$ 0.13, respectively). Retreatment rates favoured patients in the multiple fraction arm, where the likelihood of requiring re-irradiation was 2.6-fold greater in the single fraction arm (95% confidence interval: 1.92e3.47; P < 0.00001). Repeated analyses excluding drop-out patients did not alter these findings. In general, no significant differences in acute toxicities were seen.	M
119. Sahgal A, Whyne CM, Ma L, Larson DA, Fehlings MG. Vertebral compression fracture after stereotactic body radiotherapy for spinal metastases. [Review]. Lancet Oncol. 14(8):e310-20, 2013 Jul.	Review/Other-Dx	N/A	To summarise the evidence and predictive factors for vertebral compression fracture (VCF) induced by spinal stereotactic body radiotherapy (SBRT), review the pathophysiology of VCF in the metastatic spine, and discuss strategies used to prevent and manage this potentially disabling complication.	No results stated in abstract.	4
120. Cruz JP, Sahgal A, Whyne C, Fehlings MG, Smith R. Tumor extravasation following a cement augmentation procedure for vertebral compression fracture in metastatic spinal disease. J Neurosurg Spine. 21(3):372-7, 2014 Sep.	Review/Other-Dx	2 cases.	To describe 2 cases of post-balloon kyphoplasty (BKP) "tumor extravasation." This paper seeks to alert clinicians to this potential complication of BKP in the setting of epidural tumor.	No results stated in abstract.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
121. Anchala PR, Irving WD, Hillen TJ, et al. Treatment of metastatic spinal lesions with a navigational bipolar radiofrequency ablation device: a multicenter retrospective study. <i>Pain Physician</i> . 2014;17(4):317-327.	Experimental-Dx	92 patients	To report the safety and efficacy of radiofrequency ablation (RFA) of malignant spinal lesions using a novel RFA bipolar tumor ablation system which includes a navigational electrode containing 2 active thermocouples.	RFA was technically successful in all of the lesions without complication or thermal injury. Our study demonstrated significant ($P < 0.01$) decreases in the Visual analogue scale (VAS) scores at one week, one month, and 6 months postoperatively. In our largest center, 54% of our patients experienced a decrease and 30% had no change in their pain medications postoperatively. Sixtytwo percent of the spinal lesions in this largest institution were located in the posterior vertebral body. Post-ablation imaging confirmed size of ablation zones consistent with that measured by the thermocouples.	3
122. Tomasian A, Wallace A, Northrup B, Hillen TJ, Jennings JW. Spine Cryoablation: Pain Palliation and Local Tumor Control for Vertebral Metastases. <i>AJNR Am J Neuroradiol</i> . 37(1):189-95, 2016 Jan.	Observational-Dx	14 patients	To assess the safety and effectiveness of percutaneous imaging-guided spine cryoablation for pain palliation and local tumor control for vertebral metastases.	Thirty-one tumors were ablated in 14 patients (9 women and 5 men; 20–73 years of age; mean age, 53 years). The most common tumor location was in the lumbar spine (n 14, 45%), followed by the thoracic spine (n 8, 26%), sacrum (n 6, 19%), coccyx (n 2, 6%), and cervical spine (n 1, 3%). There were statistically significant decreases in the median numeric rating scale score and analgesic usage at 1-week, 1-month, and 3-month time points ($P .001$ for all). Local tumor control was achieved in 96.7% (30/31) of tumors (median follow-up, 10 months). Two patients had transient postprocedural unilateral lower extremity radiculopathy and weakness.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
123. Callstrom MR, Dupuy DE, Solomon SB, et al. Percutaneous image-guided cryoablation of painful metastases involving bone: multicenter trial. <i>Cancer</i> . 119(5):1033-41, 2013 Mar 01.	Observational-Dx	61 patients	To describe the results of a single-arm multicenter clinical trial using image-guided percutaneous cryoablation for the palliation of painful metastatic tumors involving bone.	A total of 69 treated tumors ranged in size from 1 to 11 cm. Prior to cryoablation, the mean score for worst pain in a 24-hour period was 7.1/10 with a range of 4/10 to 10/10. At 1, 4, 8, and 24 weeks after treatment, the mean score for worst pain in a 24-hour period decreased to 5.1/10 (P<.0001), 4.0/10 (P<.0001), 3.6/10 (P<.0001), and 1.4/10 (P<.0001), respectively. One of 61 (2%) patients had a major complication with osteomyelitis at the site of ablation.	2
124. Kurup AN, Callstrom MR. Ablation of musculoskeletal metastases: pain palliation, fracture risk reduction, and oligometastatic disease. [Review]. <i>Tech Vasc Interv Radiol</i> . 16(4):253-61, 2013 Dec.	Review/Other-Dx	N/A	To review current practices of percutaneous ablation of musculoskeletal metastases with an emphasis on radiofrequency ablation and cryoablation of painful skeletal metastases.	No results stated in abstract.	4
125. McMenemy BP, Kurup AN, Johnson GB, et al. Percutaneous cryoablation of musculoskeletal oligometastatic disease for complete remission. <i>J Vasc Interv Radiol</i> . 24(2):207-13, 2013 Feb.	Observational-Dx	282 patients	To assess the safety and effectiveness of percutaneous cryoablation to treat limited metastases to the musculoskeletal system, with the goal of complete disease remission.	Local control was achieved in 45 of 52 tumors (87%; 95% confidence interval [CI], 75%–93%) at a median follow-up of 21 months (range, 4–62 mo). Thirteen of 19 treated bone metastases (68%) and 32 of 33 soft-tissue metastases (97%) showed local control (P¼ .007). One- and 2-year overall survival rates were 91% (95% CI, 75%–97%) and 84% (95% CI, 65%–93%), respectively. Median overall survival was 47 months (95% CI, 26–62 mo). One- and 2-year disease-free survival rates were 22% (95% CI, 11%–37%) and 7% (95% CI, 0 1% to 26%), respectively. Median disease-free survival was 7 months (95% CI, 5–10 mo). Two of 40 procedures (5%) were associated with major complications.	2

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
126. Wallace AN, Tomasian A, Vaswani D, Vyhmeister R, Chang RO, Jennings JW. Radiographic Local Control of Spinal Metastases with Percutaneous Radiofrequency Ablation and Vertebral Augmentation. <i>AJNR Am J Neuroradiol.</i> 37(4):759-65, 2016 Apr.	Observational-Dx	55 spinal metastases	To evaluate the rate of radiographic local control of spinal metastases treated with combination radiofrequency ablation and vertebral augmentation.	Fifty-five tumors met study inclusion criteria. Radiographic local tumor control rates were 89% (41/46) at 3 months, 74% (26/35) at 6 months, and 70% (21/30) at 1 year after treatment. Clinical follow-up was available in 93% (51/55) of cases. The median duration of clinical follow-up was 34 weeks (interquartile range, 15–89 weeks), during which no complications were reported and no patients had clinical evidence of metastatic spinal cord compression at the treated levels.	2
127. Dupuy DE, Liu D, Hartfeil D, et al. Percutaneous radiofrequency ablation of painful osseous metastases: a multicenter American College of Radiology Imaging Network trial. <i>Cancer.</i> 116(4):989-97, 2010 Feb 15.	Experimental-Dx	55 patients	To determine whether radiofrequency ablation (RFA) can safely reduce pain from osseous metastatic disease.	Fifty-five patients completed RFA. Grade 3 toxicities occurred in 3 of 55 (5%) patients. RFA reduced pain at 1 and 3 months for all pain assessment measures. The average increase in pain relief from pre-RFA to 1-month follow-up is 26.3 (95% confidence interval [CI], 17.7-34.9; P <.0001), and the increase from pre-RFA to 3-month follow-up is 16.38 (95% CI, 3.4-29.4; P¼.02). The average decrease in pain intensity from pre-RFA to 1-month follow-up was 26.9 (P <.0001) and 14.2 for 3-month follow-up (P¼.02). The odds of lower pain severity at 1-month follow-up were 14.0 (95% CI, 2.3-25.7; P <.0001) times higher than at pre-RFA, and the odds at 3-month follow-up were 8.0 (95% CI, 0.9-15.2; P <.001) times higher than at pre-RFA. The average increase in mood from pre-RFA to 1-month follow-up was 19.9 (P <.0001) and 14.9 to 3-month follow-up (P¼.005).	2

Management of Vertebral Compression Fractures
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
128. Goetz MP, Callstrom MR, Charboneau JW, et al. Percutaneous image-guided radiofrequency ablation of painful metastases involving bone: a multicenter study. <i>J Clin Oncol.</i> 22(2):300-6, 2004 Jan 15.	Experimental-Dx	43 patients	To determine the benefit of radiofrequency ablation (RFA) in providing pain relief for patients with refractory pain secondary to metastases involving bone.	Forty-three patients were treated (median follow-up, 16 weeks). Before RFA, the mean score for worst pain was 7.9 (range, 4/10 to 10/10). Four, 12, and 24 weeks following treatment, worst pain decreased to 4.5 (P <.0001), 3.0 (P <.0001), and 1.4 (P <.0005), respectively. Ninety-five percent (41 of 43 patients) experienced a decrease in pain that was considered clinically significant. Opioid usage significantly decreased at weeks 8 and 12. Adverse events were seen in 3 patients and included (1) a second-degree skin burn at the grounding pad site, (2) transient bowel and bladder incontinence following treatment of a metastasis involving the sacrum, and (3) a fracture of the acetabulum following RFA of an acetabular lesion.	2
129. Hillen TJ, Anchala P, Friedman MV, Jennings JW. Treatment of metastatic posterior vertebral body osseous tumors by using a targeted bipolar radiofrequency ablation device: technical note. <i>Radiology.</i> 273(1):261-7, 2014 Oct.	Observational-Dx	26 patients	To evaluate the feasibility of use and safety of a targeted radiofrequency ablation (RFA) device for metastatic posterior vertebral body tumors.	Four of 26 patients developed transient radicular symptoms after ablation, which resolved with transforaminal blocks. No permanent neurologic injuries resulted from the procedure. Intraprocedural imaging demonstrated that the articulating bipolar instrument could be navigated into the posterior vertebral body tumors with a transpedicular approach. Postablation imaging confirmed necrosis within the ablation zone. Three patients showed progression of disease at the treated levels at follow-up. Systemic therapy was not interrupted to perform the procedures.	3

Management of Vertebral Compression Fractures
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
130. Wallace AN, Greenwood TJ, Jennings JW. Radiofrequency ablation and vertebral augmentation for palliation of painful spinal metastases. <i>J Neurooncol.</i> 124(1):111-8, 2015 Aug.	Observational-Dx	72 RFA; 110 spinal metastases	To report the experience of performing radiofrequency ablation (RFA) and vertebral augmentation of spinal metastases for pain palliation.	Mean and median pre-procedure pain scores were 8.0 ± 1.9 and 8.0, respectively. Patients reported clinically significant decreased pain scores at both 1-week (mean, 3.9 ± 3.0 ; median, 3.25; $P<0.0001$) and 4-week (mean, 2.9 ± 3.0 ; median, 2.75; $P<0.0001$) follow-up. No major complications occurred related to RFA and there were no instances of symptomatic cement extravasation.	2
131. Lutz S, Berk L, Chang E, et al. Palliative radiotherapy for bone metastases: an ASTRO evidence-based guideline. [Review]. <i>Int J Radiat Oncol Biol Phys.</i> 79(4):965-76, 2011 Mar 15.	Review/Other-Tx	4,287 candidate original research articles	To present guidance for patients and physicians regarding the use of RT in the treatment of bone metastases according to current published evidence and complemented by expert opinion.	EBRT continues to be the mainstay for the treatment of pain and/or prevention of the morbidity caused by bone metastases. Various fractionation schedules can provide significant palliation of symptoms and/or prevent the morbidity of bone metastases. The evidence for the safety and efficacy of repeat treatment to previously irradiated areas of peripheral bone metastases for pain was derived from both prospective studies and retrospective data, and it can be safe and effective. The Task Force recommended that the use of SBRT be limited to highly selected patients and preferably within a prospective trial. RT is a successful and time efficient method by which to palliate pain and/or prevent the morbidity of bone metastases. This Guideline reviews the available data to define its proper use and provide consensus views concerning contemporary controversies or unanswered questions that warrant prospective trial evaluation.	4

Management of Vertebral Compression Fractures
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
132. Tseng CL, Eppinga W, Charest-Morin R, et al. Spine Stereotactic Body Radiotherapy: Indications, Outcomes, and Points of Caution. <i>Global spine j.</i> 7(2):179-197, 2017 Apr.	Meta-analysis	N/A	To provide a technical review of spine stereotactic body radiotherapy (SBRT) planning and delivery, indications for treatment, outcomes, complications, and the challenges of response assessment. The surgical approach to spinal metastases is discussed with an overview of emerging minimally invasive techniques.	The optimal management of patients with spinal metastases is complex and requires multidisciplinary assessment from an oncologic team that is familiar with the shifting paradigm as a consequence of evolving techniques in surgery and stereotactic radiation, as well as new developments in systemic agents. The Spinal Instability Neoplastic Score and the epidural spinal cord compression (Bilsky) grading system are useful tools that facilitate communication among oncologic team members and can direct management by providing a baseline assessment of risks prior to therapy. The combined multimodality approach with "separation surgery" followed by postoperative spine SBRT achieves thecal sac decompression, improves tumor control, and avoids complications that may be associated with more extensive surgery.	Inadequate
133. Chang EL, Shiu AS, Mendel E, et al. Phase I/II study of stereotactic body radiotherapy for spinal metastasis and its pattern of failure. <i>J Neurosurg Spine.</i> 7(2):151-60, 2007 Aug.	Observational-Dx	63 patients	To report data concerning the safety, effectiveness, and patterns of failure obtained in a Phase I/II study of stereotactic body radiotherapy (SBRT) for spinal metastatic tumors.	The median tumor volume of 74 spinal metastatic lesions was 37.4 cm ³ (range 1.6-358 cm ³). No neuropathy or myelopathy was observed during a median follow-up period of 21.3 months (range 0.9-49.6 months). The actuarial 1-year tumor progression-free incidence was 84% for all tumors. Pattern-of-failure analysis showed two primary mechanisms of failure: 1) recurrence in the bone adjacent to the site of previous treatment, and 2) recurrence in the epidural space adjacent to the spinal cord. Grade 3 or 4 toxicities were limited to acute Grade 3 nausea, vomiting, and diarrhea (one case); Grade 3 dysphagia and trismus (one case); and Grade 3 noncardiac chest pain (one case). There was no subacute or late Grade 3 or 4 toxicity.	2

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
134. Gerszten PC.. Spine metastases: from radiotherapy, surgery, to radiosurgery. [Review]. Neurosurgery. 61 Suppl 1:16-25, 2014 Aug.	Review/Other-Dx	N/A	To guide systemic therapy, radiation therapy, and surgery in the setting of spinal metastases.	No results stated in abstract.	4
135. Gerszten PC, Burton SA, Ozhasoglu C, Welch WC. Radiosurgery for spinal metastases: clinical experience in 500 cases from a single institution. Spine. 32(2):193-9, 2007 Jan 15.	Experimental-Dx	393 patients	To evaluate the clinical outcomes of single-fraction radiosurgery as part of the management of metastatic spine tumors.	The maximum intratumoral dose ranged from 12.5 to 25 Gy (mean 20). Tumor volume ranged from 0.20 to 264 mL (mean 46). Long-term pain improvement occurred in 290 of 336 cases (86%). Long-term tumor control was demonstrated in 90% of lesions treated with radiosurgery as a primary treatment modality and in 88% of lesions treated for radiographic tumor progression. Twenty-seven of 32 cases (84%) with a progressive neurologic deficit before treatment experienced at least some clinical improvement.	2
136. Body JJ, Diel IJ, Lichinitser MR, et al. Intravenous ibandronate reduces the incidence of skeletal complications in patients with breast cancer and bone metastases. Ann Oncol. 14(9):1399-405, 2003 Sep.	Experimental-Dx	466 patients	To compare the efficacy of the new potent bisphosphonate, ibandronate, with placebo as intravenous (i.v.) therapy in metastatic bone disease due to breast cancer.	Skeletal morbidity period rate (SMPR) was lower in both ibandronate groups compared with the placebo group; the difference was statistically significant for the ibandronate 6 mg group (P = 0.004 versus placebo). Consistent with the SMPR, ibandronate 6 mg significantly reduced the number of new bone events (by 38%) and increased time to first new bone event. Patients on ibandronate 6 mg also experienced decreased bone pain scores and analgesic use. Treatment with ibandronate was well tolerated.	1

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
137. Virk MS, Han JE, Reiner AS, et al. Frequency of symptomatic vertebral body compression fractures requiring intervention following single-fraction stereotactic radiosurgery for spinal metastases. <i>Neurosurg Focus.</i> 2017;42(1):E8.	Observational-Dx	323 patients	To determine the rate of symptomatic vertebral body compression fractures (VCFs) requiring kyphoplasty or surgery in patients treated with 24-Gy single-fraction stereotactic radiosurgery (SRS).	Three hundred twenty-three patients who had undergone single-fraction SRS between C-1 and L-5 were included in this analysis. The cumulative incidence of VCF 5 years after SRS was 7.2% (95% CI 4.1-10.2), whereas that of death following SRS at the same time point was 82.5% (95% CI 77.5-87.4). Twenty-six patients with 36 SRS-treated levels progressed to symptomatic VCF requiring treatment with kyphoplasty (6 patients), surgery (10 patients), or both (10 patients). The median time to symptomatic VCF was 13 months. Seven patients developed VCF at 11 levels adjacent to the SRS-treated level. Fractured levels had no evidence of tumor progression. The median SINS changed from 6.5 at SRS (interquartile range [IQR] 4.3-8.8) to 11.5 at stabilization (IQR 9-13). In patients without prior stabilization at the level of SRS, there was an association between the SINS and the time to fracture.	2
138. de Freitas RM, de Menezes MR, Cerri GG, Gangi A. Sclerotic vertebral metastases: pain palliation using percutaneous image-guided cryoablation. <i>Cardiovasc Intervent Radiol.</i> 34 Suppl 2:S294-9, 2011 Feb.	Review/Other-Dx	1 case	To report the case of a patient with painful thoracic and sacral spine sclerotic metastases successfully treated by image-guided percutaneous cryoablation with the aid of insulation techniques and thermosensors	No results stated in abstract.	4

Management of Vertebral Compression Fractures
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
139. Kurup AN, Woodrum DA, Morris JM, et al. Cryoablation of recurrent sacrococcygeal tumors. J Vasc Interv Radiol. 23(8):1070-5, 2012 Aug.	Observational-Dx	6 patients	To review the safety and efficacy of cryoablation of recurrent sacrococcygeal tumors.	Five cases of recurrent chordoma and one recurrent myxopapillary ependymoma were treated with cryoablation in six patients whose ages ranged from 31 to 80 years. The tumors measured 14–39 mm in maximal dimension. Cryoablation was performed with the use of computed tomography guidance (n = 5) or a combination of ultrasound and magnetic resonance imaging guidance (n = 1). Sterile fluid was instilled to displace adjacent bowel and/or vagina in four cases, and electromyography monitoring was performed in two cases with adjacent nerve roots. Two patients with recurrent chordoma were treated for palliation of pain, with complete pain relief in one patient (pain recurred after 6 wk) and immediate reduction in pain from a score of six to a score of two on a 10-point scale in the other (pain recurred after 7 mo). Four tumors were treated for local control, with no evidence of recurrence on follow-up imaging at 3, 6, 12, and 15 months. No serious complication occurred.	3

Management of Vertebral Compression Fractures
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
140. Greenwood TJ, Wallace A, Friedman MV, Hillen TJ, Robinson CG, Jennings JW. Combined Ablation and Radiation Therapy of Spinal Metastases: A Novel Multimodality Treatment Approach. Pain physician. 18(6):573-81, 2015 Nov.	Observational-Dx	21 patients	To evaluate the safety and efficacy of combined ablation, either radiofrequency ablation (RFA) or cryoablation, and radiation therapy (RT) in the treatment of spinal metastases.	Twenty-one patients with 36 spine metastases were treated with RT and percutaneous ablation concurrently; either RFA (21/22) or cryoablation (1/22). One patient received 2 separate RFA treatments. Overall, mean worst pain score (8.0, SD = 2.3) significantly decreased at both one week (4.3, SD = 3.1; P < .02) and 4 weeks (2.9, SD = 3.3; P < .0003). Temporary postprocedural radicular pain occurred after one RFA treatment (4.5%; 1/22). Seven patients had radiation resistant tumors (renal cell, melanoma, or sarcoma). Post-procedural imaging (median 6 months; range 2 – 27 months) showed stable treated disease in 12/13 treatments at 3 months and 10/10 at 6 months.	2
141. Fourney DR, Gokaslan ZL. Anterior approaches for thoracolumbar metastatic spine tumors. [Review] [32 refs]. Neurosurg Clin N Am. 15(4):443-51, 2004 Oct.	Review/Other-Dx	N/A	To review the anterior approaches for thoracolumbar metastatic spine tumors.	No results stated in abstract.	4

Management of Vertebral Compression Fractures
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
142. Patchell RA, Tibbs PA, Regine WF, et al. Direct decompressive surgical resection in the treatment of spinal cord compression caused by metastatic cancer: a randomised trial. <i>Lancet</i> . 366(9486):643-8, 2005 Aug 20-26.	Experimental-Tx	101 patients	To determine the value of surgery in the management of MESCC, the authors undertook a randomized trial comparing the efficacy of direct decompressive surgery plus postoperative RT with that of RT alone.	After an interim analysis the study was stopped because the criterion of a predetermined early stopping rule was met. Thus, 123 patients were assessed for eligibility before the study closed and 101 were randomized. Significantly more patients in the surgery group (42/50, 84%) than in the RT group (29/51, 57%) were able to walk after treatment (odds ratio 6.2 [95% CI; 2.0–19.8] P=0.001). Patients treated with surgery also retained the ability to walk significantly longer than did those with RT alone (median 122 days vs 13 days, P=0.003). 32 patients entered the study unable to walk; significantly more patients in the surgery group regained the ability to walk than patients in the RT group (10/16 [62%] vs 3/16 [19%], P=0.01). The need for corticosteroids and opioid analgesics was significantly reduced in the surgical group.	1
143. Tong D, Gillick L, Hendrickson FR. The palliation of symptomatic osseous metastases: final results of the Study by the Radiation Therapy Oncology Group. <i>Cancer</i> . 50(5):893-9, 1982 Sep 01.	Experimental-Dx	1016 patients	To determine the optimal palliative fractionation schedule in patients with osseous metastases.	Ninety percent of patients experienced some relief of pain and 54% achieved eventual complete pain relief. Important prognosticators included the initial pain score and the site of the primary lesions. Administration of steroid or chemotherapy during the one-month on-study period did not influence the frequency of pain relief. The low-dose, short-course schedules were as effective as the high-dose protracted programs.	1
144. Lewington VJ.. Bone-seeking radionuclides for therapy. [Review] [75 refs]. <i>J Nucl Med</i> . 46 Suppl 1:38S-47S, 2005 Jan.	Review/Other-Dx	N/A	To review bone-seeking radionuclides for therapy.	No results stated in abstract.	4

**Management of Vertebral Compression Fractures
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
145. Finlay IG, Mason MD, Shelley M. Radioisotopes for the palliation of metastatic bone cancer: a systematic review. [Review] [74 refs]. <i>Lancet Oncol.</i> 6(6):392-400, 2005 Jun.	Review/Other-Dx	N/A	To review radioisotopes for the palliation of metastatic bone cancer.	No results stated in abstract.	4
146. McConnell CT Jr, Wippold FJ 2nd, Ray CE Jr, et al. ACR appropriateness criteria management of vertebral compression fractures. <i>Journal of the American College of Radiology.</i> 11(8):757-63, 2014 Aug.	Review/Other-Dx	N/A	To update the review of management of vertebral compression fracture for both benign osteoporotic and malignant causes.	No results stated in abstract.	4
147. Rollinghoff M, Zarghooni K, Zeh A, Wohlrab D, Delank KS. Is there a stable vertebral height restoration with the new radiofrequency kyphoplasty? A clinical and radiological study. <i>European journal of orthopaedic surgery & traumatologie.</i> 23(5):507-13, 2013 Jul.	Experimental-Dx	25 patients	To evaluate whether radiofrequency kyphoplasty can restore vertebral body height in osteoporotic vertebral fractures and whether restoration of vertebral height correlates with decreased pain.	Mean age of patients was 73.8 ± 9.6 (range, 55–83); time from initial painful fracture to treatment was 3.0 weeks ± 1.2; average operative time was 23.5 min (range, 15–41). Average pain index score decreased significantly from 69 ± 8.5 preoperatively to 34.4 ± 5.9 postoperatively (p<0.001), and to 30 ± 6.3 (p<0.001) after 3 months. Mean vertebral body height, anterior edge height and kyphosis angle showed significant increases postoperatively and at 3-month follow-up (p<0.05). In two vertebrae (6.6 %), minimal, asymptomatic cement leakage occurred in the upper disc. After 2 months, one new fracture (3.3 %) was identified in the directly adjacent segment that was also successfully treated with radiofrequency kyphoplasty. There was a preliminary correlation between mean vertebral body height elevation and cement volume (r = 0.533).	2

Management of Vertebral Compression Fractures
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
148. Fisher CG, DiPaola CP, Ryken TC, et al. A novel classification system for spinal instability in neoplastic disease: an evidence-based approach and expert consensus from the Spine Oncology Study Group. [Review]. Spine. 35(22):E1221-9, 2010 Oct 15.	Review/Other-Tx	N/A	To use an evidence-based medicine process using the best available literature and expert opinion consensus to develop a comprehensive classification system to diagnose neoplastic spinal instability.	A comprehensive classification system based on patient symptoms and radiographic criteria of the spine was developed to aid in predicting spine stability of neoplastic lesions. The classification system includes global spinal location of the tumor, type and presence of pain, bone lesion quality, spinal alignment, extent of vertebral body collapse, and posterolateral spinal element involvement. Qualitative scores were assigned based on relative importance of particular factors gleaned from the literature and refined by expert consensus.	4
149. Di Staso M, Zugaro L, Gravina GL, et al. A feasibility study of percutaneous Radiofrequency Ablation followed by Radiotherapy in the management of painful osteolytic bone metastases. Eur Radiol. 21(9):2004-10, 2011 Sep.	Observational-Dx	45 patients	To determine whether Radiofrequency Ablation (RFA) followed by Radiotherapy (RT) (RFA-RT) produces better palliation in terms of pain than RT alone in patients with osteolytic bone metastases.	A complete response in terms of pain relief at 12 weeks was documented in 16.6% (5/30) and 53.3% (8/15) of the subjects treated by RT or RFA-RT, respectively (p=0.027). The overall response rate at 12 weeks was 93.3% (14 patients) in the group treated by RFA-RT and 59.9% (18 patients) in the group treated by RT (p=0.048). Although recurrent pain was documented more frequently after RT (26.6%) than after RFA-RT (6.7%) the difference did not reach statistical significance. The morbidity related to RT did not significantly differ when this treatment was associated with RFA.	2
150. Wu AS, Fourney DR. Evolution of treatment for metastatic spine disease. [Review] [67 refs]. Neurosurg Clin N Am. 15(4):401-11, 2004 Oct.	Review/Other-Dx	N/A	To review the evolution of treatment for metastatic spine disease.	No results stated in abstract.	4
151. Klimo P Jr, Schmidt MH. Surgical management of spinal metastases. [Review] [80 refs]. Oncologist. 9(2):188-96, 2004.	Review/Other-Dx	N/A	To review the surgical management of spinal metastases.	No results stated in abstract.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
152. National Institute for Health and Care Excellence. Metastatic spinal cord compression in adults: risk assessment, diagnosis and management. 2008; Available at: https://www.nice.org.uk/guidance/cg75 .	Review/Other-Dx	N/A	To provide clinical guidelines for metastatic spinal cord compression in adults.	No results stated in abstract.	4
153. George R, Jeba J, Ramkumar G, Chacko AG, Tharyan P. Interventions for the treatment of metastatic extradural spinal cord compression in adults. [Review][Update of Cochrane Database Syst Rev. 2008;(4):CD006716; PMID: 18843728]. Cochrane Database Syst Rev. (9)CD006716, 2015 Sep 04.	Meta-analysis	7 studies; 23 reports	To determine the efficacy and safety of radiotherapy, surgery and corticosteroids in Metastatic extradural spinal cord compression (MESCC).	This update includes seven trials involving 876 (723 evaluable) adult participants (19 to 87 years) in high-income countries. Most were free of the risk of bias.	Good

Management of Vertebral Compression Fractures
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
154. Maranzano E, Latini P. Effectiveness of radiation therapy without surgery in metastatic spinal cord compression: final results from a prospective trial. <i>Int J Radiat Oncol Biol Phys.</i> 32(4):959-67, 1995 Jul 15.	Experimental-Dx	209 patients	To assess the effectiveness of radiation therapy (RT) in metastatic spinal cord compression (MSCC).	Back pain total response rate was 82% (complete or partial response or stable pain, 54, 17, or 11%, respectively). About three-fourths of the patients (76%) achieved full recovery or preservation of walking ability and 44% with sphincter dysfunction improved. Early diagnosis was the most important response predictor so that a large majority of patients able to walk and with good bladder function maintained these capacities. When diagnosis was late, tumors with favorable histologies (i.e., myeloma, breast, and prostate carcinomas) above all responded to RT. Duration of response was also influenced by histology. Favorable histologies are associated to higher median response (myeloma, breast, and prostate carcinomas, 16,12, and 10 months, respectively). Median survival time was 6 months, with a 28% probability of survival for 1 year. Survival time was longer for patients able to walk before and/or after RT, those with favourable histologies, and females. There was agreement between patient survival and duration of response, systemic relapse of disease being generally the cause of death.	2
155. Redmond KJ, Lo SS, Fisher C, Sahgal A. Postoperative Stereotactic Body Radiation Therapy (SBRT) for Spine Metastases: A Critical Review to Guide Practice. [Review]. <i>Int J Radiat Oncol Biol Phys.</i> 95(5):1414-28, 2016 Aug 01.	Review/Other-Tx	N/A	To discuss the rationale for treatment, describe those factors affecting surgical decision making, introduce modern surgical trends, and summarize treatment outcomes for both conventional postoperative external beam radiation therapy and postoperative spine SBRT	No results stated in the abstract.	4

Evidence Table Key

Study Quality Category Definitions

- *Category 1* The study is well-designed and accounts for common biases.
- *Category 2* The study is moderately well-designed and accounts for most common biases.
- *Category 3* There are important study design limitations.
- *Category 4* The study is not useful as primary evidence. The article may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus. For example:
 - a. The study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
 - b. The study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
 - c. The study is an expert opinion or consensus document.
- Meta-analysis
 - a. *Good quality* – the study design, methods, analysis, and results are valid and the conclusion is supported.
 - b. *Inadequate quality* – the study design, analysis, and results lack the methodological rigor to be considered a good meta-analysis study.

Abbreviations Key

Dx = Diagnostic

Tx = Treatment