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REVIEW ARTICLE

Osteoporotic vertebral fractures and the role of Percutaneous Vertebroplasty in patient care

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ABSTRACT

Background: Osteoporosis is an age-related skeletal condition of bone, with increasing prevalence in older populations. Insufficiency of the bone is associated with increased disability and mortality. Vertebral fractures are commonly secondary to osteoporosis, however only a proportion of patients may present clinically with identifiable symptoms. Percutaneous vertebroplasty is an interventional method of managing such patients.

Aim: To determine the role of percutaneous vertebroplasty in managing patients with osteoporotic vertebral fractures.

Methods: Electronic databases including MEDLINE, Cochrane Library and NHS Evidence were searched for meta-analyses and randomised controlled trials, with some provision given to expert reviews due to the small pool of publications available. Search terms used included "osteoporosis and vertebral fractures", "vertebroplasty and osteoporosis", "percutaneous vertebroplasty in the management of osteoporosis", "vertebral body cement augmentation", and "balloon kyphoplasty".

Results: Vertebroplasty reduces pain in the short-term (up to 2 weeks) after surgery and has sustained effects in improving quality of life. The long-term effects are difficult to establish due to the underlying osteoporosis disease progression and comorbidities.

Conclusion: Vertebroplasty is worthwhile in treating acute vertebral fractures associated with pain. However more research is needed to fully determine its effectiveness in the long term.

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Introduction

Osteoporosis is a systemic skeletal condition affecting populations worldwide, causing an estimated 8.9 million fractures each year.[1] The increase in bone damage and thus subsequent fragility fractures result from the reduction in bone mass and changes in the micro-architecture of bone tissue, which characterises osteoporosis.[2] As the likelihood of fracture and thus mortality increases with age,[3] treating osteoporosis and associated fractures in the ageing population may increase the financial strain on the healthcare service. The three commonest osteoporotic fractures are those of the distal radius, proximal femur, and vertebrae.[3] In the UK, the cost of treating all osteoporotic fractures in postmenopausal women has been predicted to exceed £2.1 billion by 2020.[4]

The spectrum of symptoms associated with vertebral fractures can range from asymptomatic to severe debilitating pain. Conservative management with analgesia does not always serve as a satisfactory treatment option for patients and, in such cases, a procedure such as vertebroplasty may be considered. This review aims to consider the literature surrounding this intervention to determine its role in current and future management of osteoporotic vertebral fractures.

Methods

Relevant resources were identified from a search of the MEDLINE database. Broad search terms such as "osteoporosis and vertebral fractures" were used initially, before refining to "percutaneous vertebroplasty in the management of osteoporosis", which returned 93 publications when restricted to those in English. The dates of publication were not limited. The Cochrane Library yielded a further 8 results from the search terms "vertebroplasty and osteoporosis". NHS Evidence was used for contributing evidence as well as current recommended guidelines surrounding the topic; search terms such as "vertebral body cement augmentation" and "balloon kyphoplasty" were used.

Initial studies were selected by their titles and abstracts, with focus on osteoporotic vertebral fractures and the specific mention of intervention by vertebroplasty, with or without comparison with other methods of management and treatment. Particular care was given to include highly graded evidence such as systematic reviews and randomised controlled trials; however, due to the sparse nature of current research, expert opinion reviews were also included.

Vertebral Fractures

Vertebral fractures are an example of an osteoporotic fragility fracture; that is, a low trauma fracture experienced from the force equivalent to a fall from standing height or less, exacerbated by the reduction in bone density characteristic of osteoporosis.[3] However, despite osteoporosis being the commonest cause of vertebral fracture, it is also relevant to note vertebral fractures can be caused by trauma or malignancy.[5]

Approximately one-third of vertebral fractures present clinically with identifiable symptoms.[6] They are difficult to diagnose at presentation, compounded by the low-impact trauma nature of the mechanism of injury which the patient may not be able to recollect. Therefore, recognition of clinical features or incidental imaging may give the first indication of a possible injury. Clinical features that would suggest the presence of a vertebral fracture are loss of height, exaggerated kyphosis of the spine, and back pain – typically in the thoracic or lumbar spine – as well as respiratory and gastrointestinal problems in more severe cases[7]; all of which can impact on one's daily activities and quality of life. Pain experienced in conjunction with a vertebral fracture is most prominent in the initial weeks following injury; however, pain does not subside for all patients during this time period and may last for months.[8]

According to the classification formulated by Genant *et al.*, a loss of 20% or more of the vertebral height constitutes a fracture.[9] The three categories of vertebral fracture – wedge, biconcave, and crush – can be seen in Figure 1,[10] with wedge fractures being the most common in osteoporotic patients.[11]

Vertebral fractures may be distinguished by comparison of anterior, mid, and posterior vertebral height. For example, a wedge fracture may exhibit a loss of anterior vertebral height. A lateral radiograph allows the vertebrae to be assessed for the presence or absence of these described fractures. While CT imaging gives a more comprehensive three-dimensional view, further detail and ageing of fractures is difficult. One review mentions the role of the bone scan in ageing

fractures[7] while another study reports favouring it for distinguishing between painful and healed fractures as it provides a functional assessment of bone turnover.[12] MRI is another imaging modality often considered owing to its strength at accurately pinpointing the level of injury as well as differentiating between fractures of different ages by the presence of bone marrow oedema. A small retrospective study concluded that MRI was equivalent to bone scanning in selecting patients suitable for vertebroplasty. MRI has the potential to expand into using short tau inversion recovery (STIR) sequences though more research needs to be undertaken to determine its efficacy.[13] A suitable imaging technique should be employed for assessment and planning of a vertebroplasty, with emphasis on detection of more recent fractures.

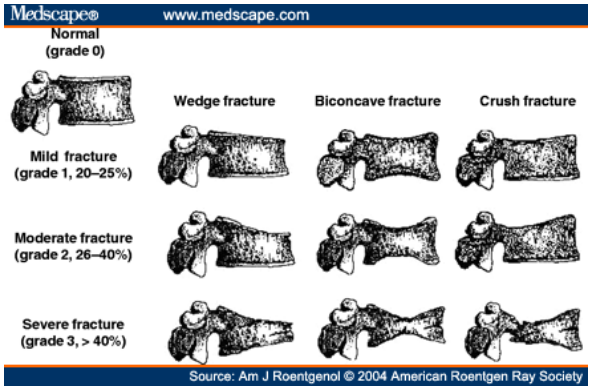

Figure 1

The current treatment of osteoporotic vertebral fractures as recommended by NICE aims to "restore mobility, reduce pain and minimise the incidence of new fractures". This may comprise analgesia, physical therapy, and a well-established regimen of pharmacological agents to manage ongoing osteoporosis, as well as interventional treatments such as percutaneous vertebroplasty and balloon kyphoplasty.[8] This review will solely discuss the use of vertebroplasty in treating vertebral fractures.

Outline of vertebroplasty procedure

Percutaneous vertebroplasty is a minimally invasive surgical procedure. First used in 1987 for the treatment of haemangiomas, it later became a management option in osteoporosis. It involves the injection of bone cement, typically polymethylmethacrylate (PMMA), into a fractured vertebra, carried out under fluoroscopy guidance. Entry is gained through the pedicle of the vertebra, and the approach may be unilateral or bilateral.

The procedure can be performed under local or general anaesthetic, with the patient in a prone position. After the PMMA has been injected, the patient must then lie supine for approximately 1 hour to allow the cement to harden.[14]

Benefits of vertebroplasty

Current research into patients eligible for vertebroplasty focuses on two main areas: duration of back pain and age of fracture. However, these tend to be used interchangeably as back pain only occurs in symptomatic patients so it is assumed to correspond to the age of fracture. All randomised controlled studies used MRI[15-19] to identify the presence of a fracture line or oedema in the vertebral body to indicate a vertebral fracture. However, studies varied in their stipulated limit for duration of back pain, from 2 weeks[16] up to 1 year.[17,18,] Localised pain at or adjacent to the level of the vertebral fracture shows significant association with improvement in pain levels following vertebroplasty as the localised pain helped the procedure to be targeted accurately.[20]

One of the key beneficial outcomes of vertebroplasty is that it provides a statistically significant decrease in pain immediately after surgery. A Canadian meta-analysis quantified this as a 50–80% reduction, which remained for up to 2 weeks.[21] This was apparent when compared with both optimal medical management and a false procedure (where just local anaesthetic was injected). NICE, in 2013, carried out their own systematic review of the major evidence in patients with recent vertebral fractures ("recent" judged by NICE to be less than 6 weeks) and came to a similar conclusion.[8] One of the largest randomised controlled trials, VERTOS II, showed statistically significant pain relief at 1 month, which was sustained for 1 year when compared with conservative management. Nonetheless this trial only included acute fractures (aged under 6 weeks as opposed to under 1 year as in some trials) and concluded that, in a select subgroup of these patients with persistent pain, vertebroplasty was a safe and cost-effective treatment.[19] The mechanism for this improvement is not currently known, however one theory is that the cement interdigitating with the cancellous bone provides mechanical stability (as proven in joint replacements), which allows for biological healing of the fractured bone.[22] Another proposed mechanism

for pain relief is through thermal cautery of the nerve endings, though this is perhaps less probable.[21]

Furthermore, though mortality was not an outcome measured in the majority of the relevant research, it seems that vertebroplasty not only maintains but may even prolong life in comparison with medical management.[8] One of the larger randomised controlled trials had significant improvements in quality of life assessed using the Oswestry Disability Index (ODI) at 1 week post-procedure, a reduction of 14 points (95% CI: −15.0 to −12.82, *p*-value <0.028) which was maintained over 36 months, where 4 points is the minimum for a clinical difference in back pain.[15] Several studies used other indices and questionnaires to assess functionality and quality of life, with some good results, however not all reported the exact statistical data.[8,17-19]

Despite the cost of the procedure and the fact that it does not eliminate the use of analgesia afterwards, NICE consider vertebroplasty to be cost effective in "people who have severe ongoing pain after a recent unhealed fracture despite optimal pain management and in whom the pain has been confirmed to be at the level of the fracture by physical examination and imaging".[8] Therefore, it is also financially advantageous to offer vertebroplasty as an option for the treatment of painful osteoporotic vertebral fractures when indicated.

Disadvantages of vertebroplasty

Literature surrounding the use of vertebroplasty in managing osteoporotic vertebral fractures has become more prevalent since the first randomised controlled trials in 2007,[17,18,23] however the trial sizes tend to be small (typically fewer than 100 patients) with disparity in quality.

One of the key disadvantages of vertebroplasty is that it is difficult to establish the long-term effects of the procedure due to the progression of the underlying osteoporosis, as well as associated comorbidities. This is exemplified by the conflicting evidence from current literature regarding pain reduction in particular, as described earlier.[15-19] The VERTOS III study sought to investigate the natural course of pain in those with vertebral fractures and conservative management, concluding that it was bidirectional as half of the patients achieved pain reduction for up to 1 year.[24] This demonstrates that it is challenging to identify which results are solely due to the vertebroplasty intervention as opposed to the confounding factors; which became evidently more problematic in the long term. There has been no difference in long-term pain relief when compared with both medical management and a false procedure,[17,18] and patients presenting with pain surpassing 3 months are less likely to benefit from vertebroplasty.[19]

To expect patients to present to clinicians, confirm any vertebral fractures, and undertake a vertebroplasty assessment before completing the procedure, all in a narrow timeframe may be difficult in practice, bringing viability into question. However, this may be due to a lack of awareness, perhaps compounded by the inconsistent evidence-base — even the NICE guidelines on the recommendations are somewhat vague.[8] If trusts were to formulate clear guidelines with specific criteria for the selection of patients based on the strongest evidence (such as pain of up to 6 weeks duration) and publicise it among relevant parties, it could allow those at risk to be identified more confidently and rapidly by clinicians. Depending on the restrictions and procedure uptake rate, this may have an important effect on the cost effectiveness of vertebroplasty for individual trusts.

Furthermore, paired with any surgical procedure is the risk of complications and adverse effects, to which vertebroplasty is no exception. One review reported this rate as 1–10%.[14] The commonest complication is cement extravasation, yet this may be asymptomatic and is dependent in part, on the volume of PMMA injected. Problems associated with extravasation are neural damage, cement emboli formation, thermal injury to surrounding structures, and the possibility of adjacent fracture or re-fracture.[14,20] Figure 2 shows the extravasation of bone cement into the intervertebral disc[5] (depicted by the arrow) in comparison to Figure 3 which shows a successful vertebroplasty of the L3 vertebra.[25] One randomised controlled trial reported 1 patient out of 82 had experienced symptoms associated with cement extravasation. This patient was treated with immediate decompression via a bilateral laminectomy and made a full recovery in 2 months.[15] Therefore, prompt identification of complications of the procedure with clear management instructions may effectively reduce the impact of such negative effects. Though the procedure is minimally invasive, a risk of infection and bleeding is still present and adverse reactions to the PMMA have also been recorded.[20]

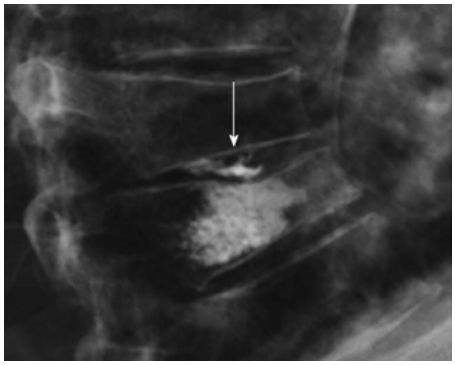

Figure 2

Figure 3

As some complications result from problems relating to the bone cement material, PMMA, there has been some keen interest in the development of new cement materials that are more physiologically compatible with bone. Examples of these biological cements are hydroxyapatite and calcium phosphate. They have the ability to integrate with patient's bone so that, in time, bone can replace the synthetic cement. One aspect of the procedure involves lying still in a supine position to allow PMMA to harden, which may be difficult in typically elderly patients and could therefore restrict certain patients from undergoing the procedure. Developments in new bone cements may negate these impracticalities. As these biological cements are more flexible, they should be more compliant in their biomechanical properties and reduce stiffness in the vertebrae, which has been hypothesised to cause adjacent vertebral fractures when overloaded with force.[5] The research into the relationship between vertebroplasty and the risk of subsequent vertebral fractures has shown that patients undergoing the procedure are at increased risk of adjacent level vertebral fractures.[26,27] This is most likely to occur within 3 months of vertebroplasty,[28] therefore minimisation of risk factors, such as having osteoporosis and intervertebral disc cement leakage is paramount.[29]

Though NICE has established vertebroplasty as a cost-effective intervention in its most recent guidance, the initial costs estimated on average at £1,472 for 1–3 vertebrae is invariably higher than that of the staggered cost of frequent analgesic medication as would be the case for conservative management. Moreover, this estimate was provided on the basis of using traditional PMMA cement.[8] However length of inpatient stay is a factor that should also be taken into consideration. One trial found that the mean duration of hospitalisation during a 12-month period of follow-up was 33.45 days in patients managed conservatively in comparison with 2.46 days in those treated with vertebroplasty.[30] This would invariably have a large impact on cost effectiveness, most likely in favour of the vertebroplasty procedure. Notwithstanding, if the spectrum of patients using vertebroplasty in the context of osteoporotic vertebral fractures was widened, this may still have a substantial effect on the cost effectiveness of the procedure, which would need to be re-evaluated as long-term results may be complicated by risk of adjacent fracture.

Conclusion

The use of percutaneous vertebroplasty for the treatment of osteoporotic vertebral fractures is still a relatively new enterprise and, inevitably, more research is needed to inform the decisions of healthcare institutions as to its appropriate use. This research should aim to introduce greater variability in patient cohorts undergoing the procedure to expand understanding about which patients will benefit most from vertebroplasty. Nonetheless, there is sufficient data to draw the conclusion that vertebroplasty is worthwhile in reducing acute pain in the case of recent fractures. Conversely, its effectiveness in the long term and effect on risk of future fractures has not been reliably quantified; therefore, continual follow-up studies should seek to monitor this. Vertebroplasty does increase the likelihood of adjacent fracture, therefore traditional medication for osteoporosis is still indicated in these patients to maintain and build bone integrity.

As an intervention, the minimally invasive surgical approach is favourable and shows equivalent or reduced mortality. Nonetheless, perhaps the greatest disadvantage of this intervention is arguably not the procedure itself, but the challenge of identifying when it may be indicated. Thus, improvements in the imaging and ageing of vertebral fractures may aid in expanding the eligible

patient pool, particularly in the treatment for acute fractures.

What is known already:	What this study adds/ highlights:
• Not all vertebral fractures present clinically, with osteoporosis being the major cause of vertebral fractures • Osteoporosis is an age-related condition of reduced bone density and altered bone structure, with increasing prevalence in older populations • Vertebroplasty is an interventional treatment which can be used for pain relief in osteoporotic vertebral fractures	• This review highlights the potential benefits and disadvantages surrounding the relatively modern treatment of percutaneous vertebroplasty. • Vertebroplasty is successful in reducing the acute pain in recent vertebral fractures

References

1. International Osteoporosis Foundation. *Facts and Statistics.* International Osteoporosis Foundation website. http://www.iofbonehealth.org/facts-statistics (accessed 3 August 2015).
2. Kumar P, Clark M. *Kumar & Clark's Clinical Medicine.* 8th Edition. Edinburgh, UK: Saunders Elsevier: 2012. p. 552.
3. National Institute of Health and Care Excellence. *Osteoporosis: Assessing the Risk of Fragility Fracture (CG146).* London, UK: National Institute of Health and Care Excellence; August 2012.
4. National Osteoporosis Society. *Key Facts & Figures.* National Osteoporosis Society website. http://www.nos.org.uk/page.aspx?pid=328 (accessed 9 December 2014).
5. Santiago FR, Chinchilla AS, Alvarez LG, Abela ALP, Mdel CG, Lopez PM. Comparative review of vertebroplasty and kyphoplasty. *World J Radiol.* 2014;6(6):329-43. DOI: 10.4329/wjr.v6.i6.329.
6. Gerdhem P. Osteoporosis and fragility fractures: vertebral fractures. *Best Prac Res Clin Rheumatol.* 2013;27(6):743-55. DOI: 10.1016/j.berh.2014.01.002.
7. Francis RM, Baillie SP, Chuck AJ, Crook PR, Dunn N, Fordham JN, *et al* . Acute and long-term management of patients with vertebral fractures. *Int J Med.* 2004;97(2):63-74. DOI: http://dx.doi.org/10.1093/qjmed/hch012.
8. National Institute of Health and Care Excellence. *Percutaneous vertebroplasty and percutaneous balloon kyphoplasty for treating osteoporotic vertebral compression fractures (TA279).* London, UK: National Institute of Health and Care Excellence; April 2013.
9. Genant HK, Wu CY, van Kuijk C, Nevitt MC. Vertebral fracture assessment using a semiquantitative technique. *J Bone Min Res.* 1993;8(9):1137-48. DOI: 10.1002/jbmr.5650080915.
10. Lenchik L, Rogers LF, Delmas PD, Genant HK. Diagnosis of osteoporotic vertebral fractures: importance of recognition and description by radiologists. *Am J Roentgenol.* 2004;183(4):949-58.
11. Alexandru D, So W. Evalulation and management of vertebral compression fractures. *The Perm J.* 2012;16(4):46-51. DOI: http://dx.doi.org/10.7812/TPP/12-037.
12. Maynard AS, Jensen ME, Schweickert PA, Marx WF, Short JG, Kallmes DF. Value of bone scan imaging in predicting pain relief from percutaneous vertebroplasty in osteoporotic vertebral fractures. *Am J Neuroradiol.* 2000;21(10): 1807-12.
13. Masala S, Schillaci O, Massari F, Danielli R, Ursone A, Fiori R, *et al.* MRI and bone scan imaging in the preoperative evaluation of painful and vertebral fractures treated with vertebroplasty and kyphoplasty. *In Vivo.* 2005;19(6):1055-60.
14. Nairn RJ, Binkhamis S, Sheikh A. Current perspectives on percutaneous vertebroplasty: current evidence/controversies, patient selection and assessment, and technique and complications. *Radiol Res Prac.* 2011;2011:175079. DOI: 10.1155/2011/175079.
15. Farrokhi MR, Alibai E, Maghami Z. Randomised controlled trial of percutanaeous vertebroplasty versus optimal medical management for the relief of pain and disability in acute osteoporotic vertebral compression fractures. *J Neurosurg: Spine.* 2011;14(5):561-9. DOI: 10.3171/2010.12.SPINE10286.
16. 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 randomised study. *Spine (Phila Pa 1976).* 2009;34(13):1349–54. DOI: 10.1097/BRS.0b013e3181a4e628.
17. Buchbinder K, Osbourne RH, Ebeling PR, Wark JD, Mitchell P, Wriedt C, *et al.* A randomised trial of vertebroplasty for painful osteoporotic vertebral fractures. *N Engl J Med.* 2009;361(6):557-68. DOI: 10.1056/NEJMoa0900429.
18. Kallmes DF, Comstock BA, Heagerty PJ, Turner JA, Wilson DJ, Diamond TH, *et al.* A randomised controlled trial of vertebroplasty for osteoporotic spine fractures. *N Engl J Med.* 2009;361(6):569-79. DOI: 10.1056/NEJMoa0900563.
19. Klazen C, Lohle P, de Vries J, Janse FH, Tielbeek AV, Blonk MC, *et al.* Vertebroplasty versus conservative treatment in acute osteoporotic vertebral compression fractures (VERTOS II): an open-label randomised trials. *Lancet.* 2010;376:1085-92. DOI: 10.1016/S0140-6736(10)60954-3.
20. Chen L, Lai P, Chen W. current status of vertebroplasty for osteoporotic compression fracture. *Chang Gung Med J.* 2011;34(4):352-9.
21. Health Quality Ontario. Percutaneous vertebroplasty for treatment of painful osteoporotic vertebral compression fractures: an evidence-based analysis. *Ont Health Technol Assess Ser.* 2010;10(19):1-45.
22. Krüger A, Oberkircher L, Kratz M, Baroud G, Becker S, Ruchholtz S. Cement interdigitation and bone-cement interface after augmenting fractured vertebrae: A cadaveric study. *Int J Spine Surg.* 2012;6:115-23. DOI: 10.1016/j.ijsp.2012.02.005.
23. Street J. *The Role of Kyphoplasty.* The Canadian Orthopaedic Association website. Updated 2013. http://www.coa-aco.org/coa-bulletin/issue-92/themes-the-role-of-kyphoplasty.html [accessed 13 June 2015).
24. Venmans A, Lohle PNM, van Rooij WJ. Pain course in conservatively treated patients with back pain and a VCF on the spine radiograph (VERTOS III). *Skeletal Radiol.* 2014;43(1):13-8. DOI: 10.1007/s00256-013-1729-x.
25. Radiological Society of North America. *Osteoporosis.* RadiologyInfo.org website. Reviewed 10 June 2015. http://www.radiologyinfo.org/en/pdf/osteoporosis.pdf (accessed 6 August 2015).
26. Mundano AS, Bian J, Cope JU, Curtis JR, Gross TP, Allison JJ, *et al.* Vertebroplasty and kyphoplasty are associated with an increased risk of secondary vertebral compression fractures: a population-based cohort study. *Osteoporos Int.* 2009;20(5):819-26. DOI: 10.1007/s00198-008-0745-5.

27. Boger A, Heini P, Windolf M, Schneider E. Adjacent vertebral failure after vertebroplasty: a biomechanical study of low-modulus PMMA cement. *Eur Spine J*. 2007;16(12):2118-25. DOI: 10.1007/s00586-007-0473-0.
28. Trout AT, Kallmes DF, Kaufmann TJ. New fractures after vertebroplasty: adjacent fractures occur significantly sooner. *Am J Neuroradiol*. 2006;27(1):217-23.
29. Rho Y-J, Choe WJ, Chun YI. Risk factors predicting the new symptomatic vertebral compression fractures after percutaneous vertebroplasty or kyphoplasty. *Eur Spine J*. 2012;21(5):905-11. DOI: 10.1007/s00586-011-2099-5.
30. Masala S, Ciarrapico AM, Konda D, Vinicola, Mammacuri M, Simonetti G. Cost-effectiveness of percutaneous vertebroplasty in osteoporotic vertebral fractures. *Eur Spine J*. 2008;17(9):1242-50. DOI: 10.1007/s00586-008-0708-8.