



Clinical outcomes of sacroplasty for metastatic sacral tumours: a systematic review and meta-analysis

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Abstract

Study design A systematic review and meta-analysis.

Objective The purpose of this study was to evaluate the clinical outcome and safety of sacroplasty for patients with secondary metastatic lesions to the sacrum.

Methods Several databases, including the Cochrane library, PubMed and EMBASE, were systematically searched to identify potentially eligible articles in English language. All the above databases were searched until December 2019. The search strategy was based on the combination of the following keywords: sacroplasty AND secondary tumours OR metastasis OR metastases. The reference list of the selected literature was also reviewed and a standard PRISMA template utilised.

Results From a total of 102 articles initially identified, a final seven studies were identified as meeting the inclusion criteria. A total of 107 patients from these studies were included. The follow-up ranged from immediate post-operatively to 30.5 months. The mean preoperative VAS was 8.38 (range 6.9–9.3), which improved significantly to 3.01 (range 1.12–4.7) post-operatively ($p < 0.001$). The most frequent complication reported was cement leakage, which occurred in 26 patients (25.4%), but without any neurological or other adverse sequelae.

Conclusions Sacroplasty in the management of secondary sacral tumours is a safe procedure that can achieve a significant reduction in pain, as quantified by VAS scores, and low complication rate.

Keywords Sacroplasty · Cement augmentation · Sacral metastases · Secondary tumours

Introduction

The skeleton is the third most common site of metastasis after the lung and liver, with the axial skeleton most frequently involved [1–3]. Primary spinal tumours are uncommon, but, of these, 31.5% involve the sacrum [4]. The most common primary sites for metastatic tumours of bones include the breast, lung, kidney, thyroid and prostate [2, 5]. Symptomatic spinal metastases are estimated to occur in 10–20% of all cancer patients, with the thoracic spine being

involved in 70% of these, the lumbar in 20% and the sacrum in a small minority of cases [5]. Up to 50% of spinal metastases require some form of treatment and 5–10% require surgical management [6].

For sacral metastatic lesions, the treatment is typically palliative, aiming at pain control and salvage of neurologic function [7]. Currently, the two main methods of treating sacral tumours are radiotherapy and surgery. Radiotherapy is the procedure of choice for tumours without spinal instability or neurological compromise [2]. Surgical intervention for sacral tumours is a complex endeavour. En bloc sacrectomy is a procedure with a high rate of major complications, regardless of tumour histology, often requiring readmissions and secondary interventions [8]. Surgical options for pathological sacral fractures are limited given the invasiveness and potential morbidity of open instrumented sacropelvic stabilization [9].

Sacroplasty involves the injection of *Polymethyl methacrylate* (PMMA) cement into the sacral ala in the tumour area or around the fracture zone. In the context of

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insufficiency fractures of the sacrum, sacroplasty has been shown to provide a significant improvement in pain as measured by the visual analogue scale (VAS) [10]. The procedure is also evolving as a treatment for sacral tumours; it can provide a minimally invasive alternative to other surgical procedures in cases without neurological deficit or instability, the main improvements being in pain and mobility [2]. The evidence for this has been largely based on level IV studies. Here, we review the published literature on sacroplasty for spinal tumours and summarize the clinical outcomes.

Materials and methods

Search strategy

Several databases, including the Cochrane library, PubMed and EMBASE, were systematically searched to identify potentially eligible articles. All the above databases were searched up to December 2019. The search strategy was based on the combination of the following keywords: sacroplasty, cement augmentation, secondary tumours, and sacral metastases. The reference list of selected literatures was also reviewed.

Inclusion and exclusion criteria

Inclusion criteria were established before the search, and the following criteria were used.

We limited our results to articles published in the English language that reported on and included clinical outcomes of sacroplasty in patients with secondary sacral tumours.

Exclusion criteria: (1) non-English language, (2) case reports and expert opinions, (3) no reported outcome measures, (4) sacroplasty for reasons other secondary tumours, (5) lower than 4 cases of sacroplasty and (6) repetitive studies.

A flow chart outlining the search is provided in (Fig. 1). For the assessment of evidence quality, the Oxford Centre for Evidence-Based Medicine (CEBM) grading system was utilized.

Data extraction

Each article from the primary search was individually assessed for inclusion, based on its title and abstract, according to these parameters. A second review, which included assessing the full article, was performed by the main author to further discriminate the primary findings.

For each study included in the analysis, the main author, year of publication, level of evidence and patient characteristics (per reported cohort) were tabulated, along with the follow-up data, imaging method and technique used. The

clinical outcomes as presented in the papers are shown in (Table 1), including any improvement in pain documented using the VAS and the rate and nature of any complications.

Institutional review board approval was not necessary.

Results

Type of study

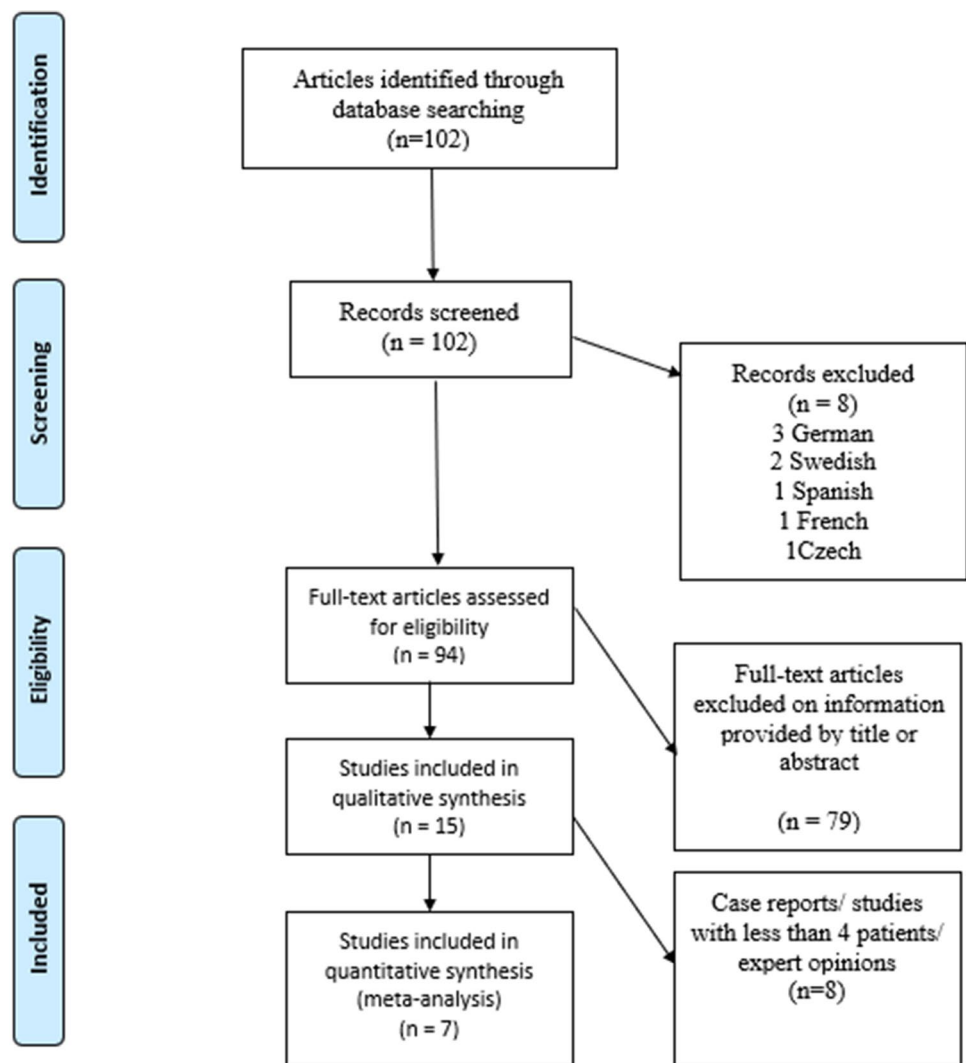
Seven papers were published in the English language literature between 1996 and 2019. There was no level I, II or III evidence available to include in our study. Four papers were retrospective case series, and three papers were prospective case series. The follow-up ranged between immediate post-operative and 30.5 months.

Sun et al. [11] studied seven patients who underwent sacroplasty for severe painful sacral metastases. Significant pain relief was reported with VAS reduction ≥ 4 points in all seven patients at 1 month after the procedure, six out of seven at 3 months and five out of seven at 6 months of follow-up. Pain relief was considered good if the score was 0–3, partial if the score was 4–6 and insufficient or null if the score was 7–10. A good level of pain relief was observed in five out of seven patients, and partial pain relief was observed for two out of seven patients, insufficient pain relief was not noticed at 1 month after the procedure. Good and partial pain relief was observed in six out of seven patients at 3 months and five out of six patients at 6 months, respectively. Cement leakage at S1 foramina was noticed in one case without clinical significance.

Andresen et al. [12] studied 10 patients who had sacroplasty for metastatic involvement of the sacrum. A significant ($p < 0.001$) reduction in pain according to the VAS occurred in all patients from 9.3 ± 0.67 (8–10) preoperatively to 2.7 ± 1.28 (1–5) on the second post-operative day and 2.9 ± 0.81 (2–5) 6 months after the intervention. No significant complications were reported.

Georgy et al. [13] studied 12 patients with malignant metastatic lesions of the sacrum and pelvis who underwent percutaneous cement augmentation. All treated patients reported decreased pain level by VAS (except for 1 patient) within 2–4 weeks of follow-up. Average VAS score was 8.6 before the procedure and improved to 3.8 after the procedure. Three patients had minimal clinically insignificant leakage.

Basile et al. [14] studied eight patients who underwent sacroplasty for sacral multiple myelomas. All patients experienced improvements in symptoms after the procedure, as demonstrated by improved VAS scores pre-op: 7.5 ± 1.1 , post-op: 1.12 ± 1.2 and performance status and decreased analgesic dose during follow-up. One case of a small and asymptomatic foraminal leak was reported.

Fig. 1 Flow chart of the literature research

Kortman et al. [15] studied 39 patients with symptomatic sacral lesions. The average pre-treatment VAS score of 9.0 ± 0.9 in patients with sacral lesions was significantly improved after sacroplasty to 2.6 ± 2.4 ($p < 0.001$). There were no major complications or procedure-related deaths.

Moussazadeh et al. [9] studied 25 patients with cancer-associated sacral insufficiency fractures. Twenty of 25 patients (80%) had reduction in their visual analogue pain score at a median follow-up of 6.5 months; no patients were worsened. The mean visual analogue scale score decreased from 8.8 to 4.7 post-procedurally ($p < .001$). Extravertebral cement migration was noted in 18 procedures without being clinically significant. Six repeat or contralateral procedures were performed.

Tian et al. [16], studied 10 patients who underwent percutaneous sacroplasty for painful sacral metastases. The mean VAS declined significantly ($p < 0.01$) from 6.9 ± 1.2 before the procedure to 2.7 ± 1.34 after the procedure reflected by significant reduction ($p < 0.01$) in opioids use before and

after the surgery. Extrasosseous cement leakage occurred in 3 cases out of 10 without causing any clinical complications.

Clinical outcome assessment

VAS score was reported as a clinical outcome measure in all patients. The mean preoperative VAS was 8.38 (range 6.9–9.3), and the mean post-operative VAS was 3.01 (range 1.12–4.7) ($p < 0.001$, two-tailed paired t test). The improvement appeared to be maintained in all series at the latest follow-up, which ranged from immediate post-op to 30.5 months.

Complications

The only complication reported was cement leakage, which occurred in 26 patients and was without clinical significance. Figure 2 is a case illustration of sacroplasty performed for a sacral metastasis in our unit.

Table 1 Sacroplasty literature review: Authors, level of evidence, technique, outcome and complications

References	Type of study	Total patients	Mean follow-up (months)	Imaging used	Technique	Amount of cement(ml)	Anaesthesia	Outcome	Complications
Sun et al. [11]	CS(r) Level 4	7	5.7 months	F/CT	Nine patients fluoroscopic guidance only seven patients had three-dimensional C-arm Ct reformation combined with fluoroscopic guidance	4-6	Local	VAS pre-op: 8.6 VAS post-op (1 month):3.3	One cement leakage at SI foramina without clinical significance
Andresen et al. [12]	CS (pros) Level 4	10	6	CT	Short or transiliac axis	4-10	-	VAS Pre-op 9.3±0.67 (8-10) VAS Post-op 2.9±0.81 (2-5)	None reported
Georgy [13]	CS (pros) Level 4	12	2-4 weeks	Needles were placed under CT guidance, and the cement injection was performed under fluoroscopy	Transiliac in 25%	2-6	Sedation	VAS Pre-op 8.6 VAS Post-op 3.8	Three patients had minimal clinically insignificant leakage
Basile et al. [14]	CS(r) Level 4	4	12.5	F/CT	Not reported.	3 and 4 cc: mono-lateral. 8-10 cc: bilateral interventions	Local/sedation	VAS Pre-op: 7.5±1.1 VAS Post-op: 1.12±1.2	One asymptomatic foramina leak
Kortman et al. [15]	CS(r) Level 4	39	30.5	F/CT	Short axis (perpendicular to the sacral ala)	4.1	Sedation	VAS Pre-op: 9.0±0.9 VAS Post-op: 2.6±2.4	There were no procedure-related deaths, infections, pulmonary emboli, significant cement extravasations or haemorrhages

Table 1 (continued)

References	Type of study	Total patients	Mean follow-up (months)	Imaging used	Technique	Amount of cement(ml)	Anaesthesia	Outcome	Complications
Moussazadeh et al. [9]	CS(r) Level 4	25	6.5	F/CT	Short axis (perpendicular to the sacral ala) Long axis (bone needle is advanced from the inferior and dorsal aspect of the sacral ala at S4 cephalad to the S1 level.	6.49 ± 3.03	General	VAS Pre-op: 8.8 AS Post-op: 4.7	There were no cases of infection, symptomatic cement extravasation (18 cases not clinically relevant), neurological injury, or other procedural complications
Tian et al. [16]	CS (Pros) Level 4	10	Immediately post-op	Biplane fluoroscopic guidance	Interpedicular approach	5–12 ml	Local	VAS Pre-op: 6.90 ± 1.20 VAS Post-op: 2.70 ± 1.34	PMMA asymptomatic leakage was observed in 30% (3/10)

CS (pros), prospective case series; CS(r), retrospective case series; F, fluoroscopy; CT, computerised tomography; VAS, visual analogue scale, PMMA, polymethyl methacrylate

Discussion

This systematic review and meta-analysis shows that sacroplasty in the management of secondary lesions of the sacrum is a safe procedure and can result in significant reduction in pain as quantified by VAS scores and with low complication rates. Metastatic tumours of the sacrum, although less frequent than metastatic lesions of the thoracic or lumbar spine, have a devastating impact on an individual's quality of life by causing pain, functional disability, sensory/motor deficits and, eventually, bladder and bowel dysfunction [2].

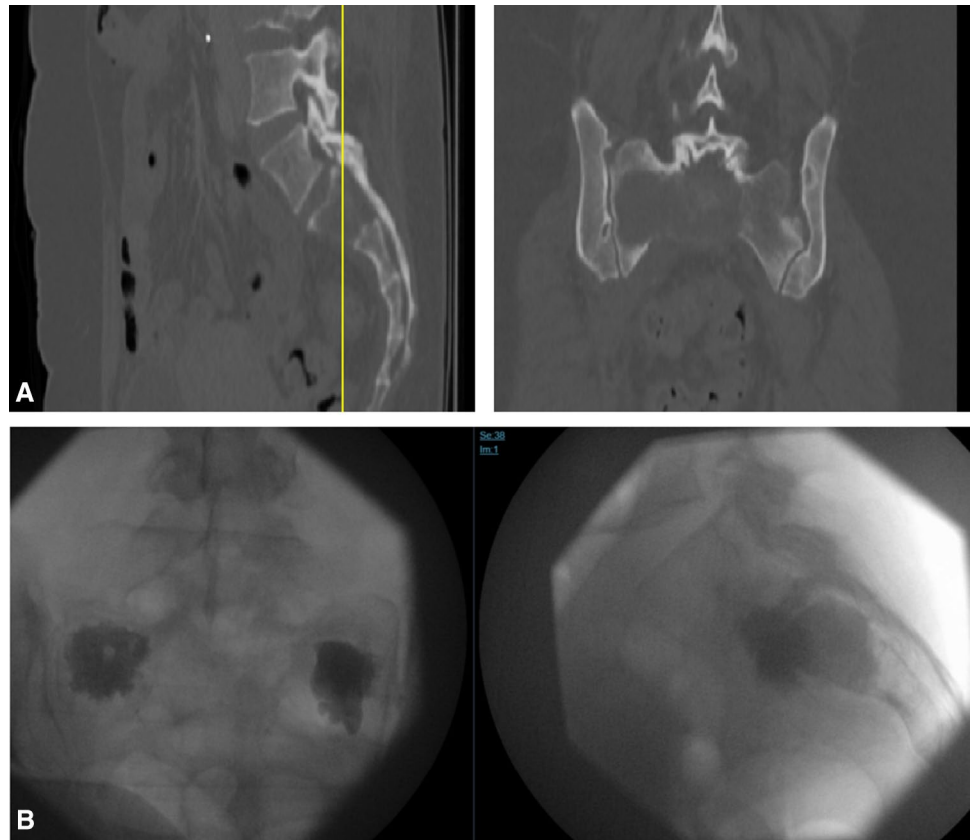
Vertebroplasty was first introduced in Amiens in 1984 by Gailbert and Deramond [17]. After a 50-year-old patient underwent laminectomy of the L2 vertebra for a haemangioma, three millilitres of bone cement were injected into the L2 vertebral body for reinforcement. Following surgery, the patient experienced complete pain relief. Since then, the procedure has been used for osteoporotic and metastatic vertebral fracture and has proven to be safe and effective in providing pain relief and improving functional outcomes in patients with vertebral body fractures [18, 19].

The main treatment options for sacral metastasis are radiotherapy and surgery. Radiotherapy is indicated in patients without spinal instability or acute neurological deterioration. There are several limitations of radiotherapy when used in the treatment of spinal metastasis. Radiosensitivity varies among tumours types. In general, prostate and lymphoid tumours are radiosensitive, breast cancer is 70% sensitive and 30% resistant, and gastrointestinal tumours, renal cell tumours and melanomas are radioresistant [2].

Pain response also varies among patients. A study by Chow assessed pain scores after radiotherapy and found that partial response (PR) rates at 2, 4, 8 and 12 weeks occurred in 44, 42, 30 and 38% of the patients, respectively, whereas complete response rates were 24, 32, 31 and 29% [20]. Complete response was defined as zero on the VAS, whereas PR was defined as a reduction of VAS score of two or more points, or a ≥ 50% reduction of the pre-treatment pain score. Pain flare is also common among patients, lasting for three days on average and occurring in nearly 40% of the patients receiving palliative radiotherapy for symptomatic bone metastases [21]. In the context of sacral insufficiency fractures, sacroplasty was found to produce significant improvements in VAS scores and was recommended as an alternative to analgesia and rehabilitation [10].

Injection of the cement seems to be related to the analgesic effect, but the exact mechanism of pain relief is not well understood. Various authors have postulated that

Fig. 2 Case example: 65-year-old male presented with secondary sacral metastases from colorectal cancer. **a** The CT shows sagittal and coronal cuts of the sacrum with tumour infiltration. **b** Intraoperative fluoroscopy of sacroplasty with AP and lateral views



stabilization of microfractures, the tumouricidal effect of cement through cytotoxic activity or thermal necrosis can play a role in pain reduction [22–25]. In any case, in our literature review, we found immediate, significant and sustained pain relief after sacroplasty for sacral metastasis. Sacroplasty could offer an alternative approach to treating painful sacral lesions where neurological deficit or instability is not present [2].

The largest series to date is presented by Pereira, who reports the results of sacroplasty in 42 patients with sacral metastasis, nine patients with insufficiency fractures and seven patients with primary sacral tumours [26]. Unfortunately, the authors did not differentiate between groups, although they performed a statistical analysis which shows no difference in clinical outcome between the three groups ($p=0.50$). Statistically significant differences were observed between pre- and post-sacroplasty mean VAS scores (Student's *t* test, $p<0.05$). They concluded that percutaneous sacroplasty for metastatic and osteoporotic fractures is a safe and effective technique in terms of pain relief and functional outcome.

Good imaging quality is a crucial factor in the success of sacroplasty. The sacrum is different from the cuboidal shape of the vertebral body in terms of its three-dimensional anatomy. In the majority of the analysed studies, fluoroscopy appears to be the main technique used, either alone or in

combination with CT. The fluoroscopy visualization seems to be the preferred imaging technique during the cement injection in order to ensure maximal bone penetration and to prevent leakage. The relationship between the cement and sacral foramina can be difficult to ascertain with standard fluoroscopy due to the oblique configuration of the sacrum and its foramina. Consequently, some authors preferred to first place the needle under CT guidance and then, visualize the cement injection under fluoroscopy [11, 13].

The most frequent complication encountered in our review was cement extravasation, which occurred in 26 patients but was asymptomatic and without clinical significance in all of them. More than half of them were reported in one study in which Moussazadeh et al. [9] reported extravertebral cement migration in 18 out of 31 sacroplasties done. However, none were clinically significant.

Conclusion

Sacroplasty in the management of secondary lesions of the sacrum is a safe procedure and can result in significant reduction in pain as quantified by VAS scores and low complication rates. This is a review of level IV studies and we cannot provide clear recommendation in favour of this procedure. However, given the significant benefits of

sacroplasty noted in this series, we feel that further studies on sacroplasty would be of great interest.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

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