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SYSTEMATIC REVIEW / *Interventional imaging*

Percutaneous extra-spinal cementoplasty in patients with cancer: A systematic review of procedural details and clinical outcomes

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KEYWORDS
Extra-spinal cementoplasty;
Osteoplasty;
Percutaneous bone consolidation;
Bone metastases;
Polymethyl methacrylate (PMMA) volume

Abstract
Purpose: To perform a systematic review of technical details and clinical outcomes of percutaneous extra-spinal cementoplasty in patients with malignant lesions.
Materials and methods: PUBMED, MEDLINE, MEDLINE in-process, EMBASE and the Cochrane databases were searched between January 1990 and February 2019 using the keywords «percutaneous cementoplasty», «percutaneous osteoplasty» and «extra-spinal cementoplasty». Inclusion criteria were: retrospective/prospective cohort with more than 4 patients, published in English language, reporting the use of percutaneous injection of cement inside an extra-spinal bone malignant tumour using a dedicated bone trocar, as a stand-alone procedure or in combination with another percutaneous intervention, in order to provide pain palliation and/or bone consolidation.
Results: Thirty articles involving 652 patients with a total of 761 lesions were reviewed. Mean size of lesion was 45 mm (range of mean size among publications: 29—73 mm); 489 lesions were located in the pelvis, 262 in the long bones of the limbs and 10 in other locations. Cementoplasty was reported as a stand-alone procedure for 60.1% of lesions, and combined with thermal ablation for 26.2% of lesions, implant devices for 12.3% of lesions, and balloon kyphoplasty for 1.4% of lesions. The mean volume of injected cement was 8.8 mL (range of mean volume among publications: 2.7—32.2 mL). The preoperative visual analogic scores ranged between 3.2 and 9.5. Postoperative scores at last available follow-up ranged from 0.4 to 5.6. Thirteen papers reported a reduction of the visual analogic scores of 5 points or more. Nerve injury was the most frequent symptomatic leakage (0.6%).

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Conclusion: Percutaneous extra-spinal cementopasty is predominantly performed as a stand-alone procedure and for lesions in the bony pelvis. It appears to be an effective tool to manage pain associated with malignant bone tumours. There is however a lack of standardization of the technique among the different publications.

Percutaneous cementoplasty has been described for the first time in 1987 for the management of an aggressive hemangioma of the axis [1]. It was then successfully applied for the treatment of painful osteoporotic and malignant vertebral compression fractures [2,3]. Hence, in patients with cancer, vertebroplasty using polymethyl methacrylate (PMMA) bone cement offers a minimally invasive solution both to alleviate the pain related to spinal metastases and to provide bone consolidation in patients with impending fracture of the vertebral body [4,5].

The management of painful malignant lesions outside the spine with cementoplasty, also known as extra-spinal cementoplasty or osteoplasty, is effective as well [6—8]. Besides pain management, bone consolidation is of utmost importance in some mechanical critical areas. For example, stand-alone cementoplasty can be applied to the acetabulum (acetabuloplasty) in order to prevent from a pathological fracture [9]. In other locations such as the long bones, PMMA can be used in combination with other devices such as nails to enhance the biomechanical stability of the surgical device [10,11]. Similarly to the spine, the antalgic effect does not seem to be related to the amount of injected cement [8,12,13]. On the other hand, it is assumed that optimal bone consolidation requires to fill as much as possible the metastatic process and the surrounding cancellous bone [8,14]. If the technique of vertebroplasty is quite well standardized, there is little literature focusing on the technique of extra-spinal cementoplasty.

The aim of this study was to perform a systematic review of technical details and clinical outcomes of percutaneous extra-spinal cementoplasty in patients with malignant lesions.

Materials and methods

Selection criteria

Informed consent was not required for this retrospective systematic review. We searched PUBMED, MEDLINE, MEDLINE in-process, EMBASE and the Cochrane databases between January 1990 and February 2019 using the following keywords «percutaneous cementoplasty», «percutaneous osteoplasty» and «extra-spinal cementoplasty». After exclusion of duplicates, the titles and abstracts of publications identified by the database search were screened for studies that potentially met the inclusion/exclusion criteria. Final eligibility was based after examination of full text. The screening was performed by two of the authors (J.G. and RL.C.). Disagreements were resolved by consensus.

The following criteria were used for selection:

- retrospective/prospective cohort of more than 4 patients;
- study published in English language;
- study reporting the use of percutaneous cementoplasty (i.e., percutaneous injection of cement inside a bone metastasis using a dedicated bone trocar, in extra-spinal locations);
- percutaneous cementoplasty was used as a stand-alone procedure or in combination with another percutaneous intervention and;
- percutaneous cementoplasty was used to provide pain palliation and/or bone consolidation.

Papers reporting the use of hollowed implants through which cement was injected (hollowed screws for example) were excluded from analysis, because the primary goal is to improve the material stability and not to fill the tumour. Studies including both spinal and extra-spinal procedures were only included if detailed data of extra-spinal interventions were accessible. Sacral cementoplasties were considered as extra-spinal cementoplasties. Commentaries, abstract, review articles and conference presentations were not included.

Methodological quality assessment

The quality of studies was evaluated with a modified version of the Newcastle-Ottawa scale [15,16]. This system evaluates the quality of non-randomized studies included in a review using a ''star system'' from 0 to 6. The higher the number of stars, the lower the risk of bias. Papers awarded with less than four stars were excluded from the present review.

Data extraction and analysis

The full text of all included papers was reviewed to collect specific items in a dedicated spreadsheet (Excel 2011, Microsoft, Seattle, WA). For each study, data on:

- patient age;
- lesion characteristics (histology, size, localisation, Harrington classification for acetabular lesions, Mirel's score for lesions located in long bones);
- performing physician (surgeon/interventional radiologist);

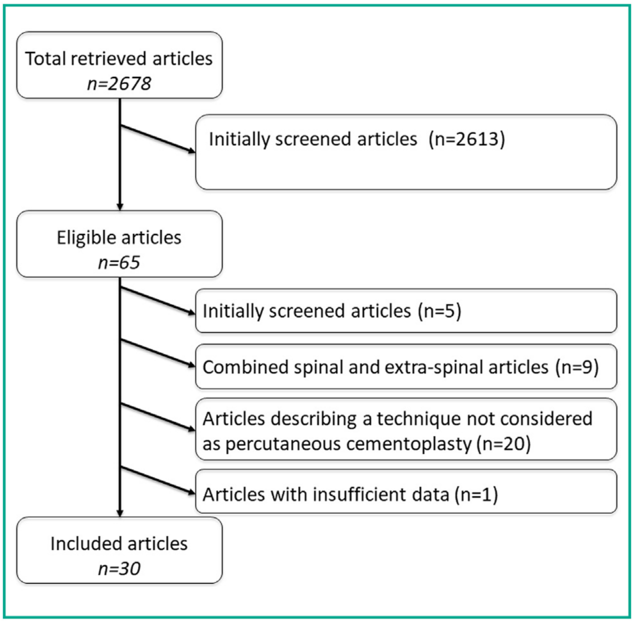

Figure 1. Flow chart of article selection.

- additional percutaneous intervention within the same session of treatment (balloon expansion, thermal ablation, implants);
- bone needle size in Gauge (G);
- volume of cement;
- degree of lesion filling;
- description of the technique for injection greater than 10 mL;
- rate of overall and symptomatic leakages;
- pain score before and after the intervention at last time point of assessment and;
- secondary fractures/surgery were extracted if available. Case by case analysis was performed whenever possible.

Descriptive statistics were computed to present results. The overall weighted mean method was used to calculate a mean value across studies whenever feasible.

Results

The first search query produced 2678 studies. After screening by title and abstracts, 65 studies were included for full text analysis. Of those, 30 fulfilled the inclusion/exclusion criteria and were therefore included for the present study (Fig. 1). No exclusions were made due to risk of bias.

Included publications were issued between 1995 and 2019. There were 20 retrospective and 6 prospective studies, while 4 articles did not clearly state whether the study was prospective or retrospective.

Patients and lesions characteristics

A total of 761 extra-spinal lesions in 652 patients (data available from all studies; number of studies n_p = 30) were treated using percutaneous cementoplasty [6—11, 14,17—39]. The mean age of the patients at the time of treatment was available/could be extracted for all studies but one (n_p = 29) and ranged between 48.6- and 69.4-years old across publications [6—11,14,17—29,31—39]. The most frequent histology was available/could be extracted for all studies (n_p = 30) [6—11,14,17—39]. Lung cancer was the most frequently reported primary tumor (11 articles), followed by breast (8 articles) and myeloma/kidney (7 articles).

Size of lesions was available in 9 studies (n_p = 9) [6,7,14,20—22,27,34,36]. The mean size was reported/could be calculated for 8 studies (n_p = 8), while one article reported only the volume of the lesions. The mean lesion size ranged from 29 mm to 73 mm across studies [6,7,14,20—22,27,36]. The mean lesion size calculated among 315 lesions (n_p = 8) using the overall weighted mean method was 45 mm [6,7,14,20—22,27,36].

Localisation of the extra-spinal lesions was available for all studies and could be divided into lesions of the pelvis (coxal bone and sacrum), of the long bones and of other bones (rib, skull) [6—11,14,17—39]. Eleven studies focused on pelvic cementoplasties, 6 on cementoplasties of the long bones and 13 included all kind of locations. Overall, 489 lesions were located in the pelvis, 262 in the long bones of the limbs and 10 in other locations (n_p = 30) (Table 1) [6—11,14,17—39]. The most frequently treated area in the coxal bone (n_p = 22) was the acetabulum (197 lesions). Only two studies over the 24 reporting percutaneous cementoplasty in the pelvis did not specify sublocation of the tumours within the coxal bone [17,22]. Grading of acetabular lesions using the Harrington classification could be extracted from 3 studies, representing a total of 55 lesions with a mean score of 2.3 [8,9,14]. Lesions of the long bones were more frequently localized (n_p = 19) in the femur (166 lesions) [6,7,10,11,17—23,27,28,30—32,35—37]. The Mirel's score, which evaluates the risk of pathological fracture for lesions of the long bones, was reported in 5 articles, with a mean score greater than 9 (over 12) in all publications [11,19,27,31,35].

Palliative pain management was the main indication for 735 lesions (n_p = 27) [6—11,17—30,32—34,36—39], while prevention of fracture was the major concern for 26 lesions (n_p = 3) [14,31,35].

Procedure details

Performing physician

The performing physician could be evaluated in all studies but one (n_p = 29) [6—11,14,17—36,38,39]. Among the 728 treatments, 613 (84.2%) were performed by interventional radiologists and 115 (15.8%) by orthopedic surgeons. Lesions treated by surgeons (n_p = 5) were located either in the long bones (*n* = 63) or the acetabulum (*n* = 52) [10,11,25,26,39]. All 63 percutaneous cementoplasties performed by surgeons for lesions of the long bones (n_p = 2) were combined with surgical stabilization using flexible (*n* = 20) or closed intramedullary (*n* = 43) nails [10,11]. There was no other extra-spinal lesion treated by surgeons. Interventional radiologists (n_p = 24) treated more lesions in the pelvis (*n* = 408) than in the long bones (*n* = 195) [6—9,14,17—24,27—36,38]. Cementoplasty without any additional implanted device was used in the majority of lesions (*n* = 166, representing 85% of the lesions) treated by interventional radiologists in the long bones [6,7,17—23,27,28,32,36]. Implant-augmented

Table 1 Included studies and procedure details.

References	Authors	Main indication for PC	No of patients	No of lesions in the pelvic bone	No of lesions in the long bones	No of lesions in other locations	Additional treatment combined with PC	Needle diameter (G)	Mean volume of injected cement (mL)	Maximal volume of cement (mL)
[7]	Couraud et al.	Pain palliation	31	47	3	1	Balloon kyphoplasty — number not reported	11	N.R	N.R
[17]	Fares et al.	Pain palliation	30	20	10	—	RFA — 30 lesions	11 or 13	2.7	N.R
[18]	Tian et al.	Pain palliation	38	46	8	—	RFA — 54 lesions	11 or 13	6.6	28
[19]	Sun et al.	Pain palliation	51	53	8	—	—	11 or 13	N.R	N.R
[6]	Iannessi et al.	Pain palliation	20	13	7	—	—	11	4.3	10
[20]	Masala et al.	Pain palliation	39	17	22	—	—	13	3	4
[21]	Basile et al.	Pain palliation	13	6	6	1	—	11 or 13	3.5 (pelvic PC)	12 (pelvic PC)
[22]	Anselmetti et al.	Pain palliation	50	26	26	6	RFA — 7 lesions	10	5.9	15
[23]	Hierholzer et al.	Pain palliation	5	4	1	—	—	N.R	17.8	36
[10]	Kim et al.	Pain palliation	15	—	20	—	Insertion of flexible nails — 20 lesions	10	15.5	31
[24]	Cotten et al.	Pain palliation	11	12	—	—	—	10	15	23
[25]	Durfee et al.	Pain palliation	11	11	—	—	Balloon kyphoplasty — 3 lesions	N.R	N.R	N.R
[26]	Maccauro et al.	Pain palliation	25	30	-	-	—	10	N.R	N.R
[27]	Cazzato et al.	Pain palliation	51	-	66	-	—	11 or 13	N.R	N.R
[28]	Munk et al.	Pain palliation	12	13	1	—	RFA — 14 lesions	8, 11 or 13	8	16
[29]	Weill et al.	Pain palliation	18	18	-	-	—	10	7.8	14
[11]	Kim et al.	Pain palliation	43	—	43	—	Intramedullary nailing — 43 lesions	11	19.1	37
[30]	Kelekis et al.	Pain palliation	12	—	12	—	Insertion of micromeshs — 12 lesions	8	N.R	N.R
[31]	Deschamps et al.	Fracture prevention	12	—	13	—	Screw fixation — 13 lesions	11	N.R	N.R
[32]	Hoffmann et al.	Pain palliation	8	6	3	—	RFA — 9 lesions	10 or 15	8	10
[8]	Moser et al.	Pain palliation	40	44	—	—	—	11 or 13	10.3	27
[33]	Kelekis et al.	Pain palliation	14	23	—	-	—	11	8	15
[34]	Wallace et al.	Pain palliation	12	12	—	—	Bipolar RFA — 12 lesions	N.R	12	30
[14]	Kurup et al.	Fracture prevention	7	7	—	—	Cryoablation and balloon kyphoplasty — 7 lesions	10	14	21
[35]	He et al.	Fracture prevention	6	—	6	—	Insertion of broken pins — 6 lesions	11 or 13	32.2	42
[36]	Toyota et al.	Pain palliation	12	12	3	2	RFA — 17 lesions	8 to 13	7	15
[37]	Wei et al.	Pain palliation	26	29	4	—	MWA — 33 lesions	13	8	14
[38]	Marcy et al.	Pain palliation	18	18	—	—	—	N.R	6	9
[9]	Colman et al.	Pain palliation	11	11	—	—	RFA — 3 lesions	N.R	N.R	N.R
[39]	Gupta et al.	Pain palliation	11	11	—	—	—	11 or 13	N.R	N.R

No: number; PC: percutaneous cementoplasty; G: gauge; N.R.: not reported; RFA: radiofrequency ablation; MWA: microwave ablation.

cementoplasties were performed for the remaining 31 lesions (15%), and included cannulated screws (*n* = 13, one study), bone puncture needles after removal of the tails and pinpoints (*n* = 6, one study) and 22 G stainless steel microneedles (*n* = 12, one study) [30,31,35].

Additional intervention

Detailed data were available for all studies but one (n_p = 29) that reported the use of balloon kyphoplasty for some pelvic lesions without further specifications [6,8–11,14,17–39]. Cementoplasty was reported as a stand-alone procedure for 427 lesions (60.1%). Kyphoplasty was performed for 10 lesions (1.4%) (n_p = 2), all located in the acetabulum [14,25]. For 186 lesions (26.2%), thermal ablation was combined to cementoplasty (n_p = 10): 134 lesions (72%) were ablated with monopolar radiofrequency ablation (RFA) (n_p = 7), 33 lesions (17.7%) with microwave (n_p = 1), 12 (6.5%) with bipolar RFA (n_p = 1) and 7 (3.8%) with cryoablation (n_p = 1) [9,14,17,18,22,28,32,34,36,37]. Localisation of the tumors that were ablated was the pelvis for 148 lesions (79.6%), the long bones for 34 lesions (18.3%) and other locations for 4 lesions (2.1%). Lesions that were cryoablated in the acetabulum all benefited from the combination of kyphoplasty and cementoplasty either the same day after cryoablation (2 patients) or the day after (5 patients) (n_p = 1) [14]. As priorly detailed, implant-augmented cementoplasty was performed for 94 lesions (12.3%) (n_p = 5), all located in the long bones [10,11,30,31,35].

Needle diameter

The needle diameter was reported in 25 articles representing 704 lesions (n_p = 25) [6–8,10,11,14,17–22,24, 26–33, 35–37,39]. Precise data could be extracted from 14 studies (379 lesions) [6,7,10,11,14,20,24,26, 29–31, 33,37,38]. The diameter of the needles in the remaining 11 studies (325 lesions) was variable, without the possibility of a case by case analysis [8,17–19,21,27, 28,32,35,36,39]. The needle diameter was 13-G for 72 lesions (10.2%) (n_p = 2), 11-G for 150 lesions (21.3%) (n_p = 5), 10-G for 145 lesions (20.6%) (n_p = 6), and 8-G for 12 lesions (1.7%) (n_p = 1). It ranged from 11- to 13 G for 285 lesions (40.5%) (n_p = 8) and from -8 to 15-G for 40 lesions (5.7%) (n_p = 3).

Volume of cement

The volume of injected cement was available in 20 studies, reported as a mean value in 11 articles and as case by case data in 9 articles [6,8–11,14,17,18,20, 22,23,26,28,29,32–38]. One study reported only the mean volume of cement for pelvic cementoplasties but not for lesions in the long bones [21]. Nine studies did not report the amount of cement [7,19,24,25,27,30,31,39].

The mean volume of cement ranged from 2.7 mL to 32.2 mL across studies (n_p = 20) (Table 1). Data from these 20 studies were extracted and used to calculate a mean volume using the overall weighted mean method. Hence, the mean volume was 8.8 mL among the 485 lesions used for statistical evaluation (n_p = 20). More specifically, data for pelvic injections could be extracted from 13 studies: the mean volume calculated over 188 lesions (n_p = 13) was 9.1 mL (Table 2). The maximal reported volume for a pelvic osteoplasty was 36 mL [23]. For long bones, data from 8 studies were extracted: the mean volume was calculated over 84 lesions (n_p = 8) and was 16.9 mL (Table 2). Maximal reported volume for a cementoplasty in a long bone was 42 mL [35]. Detailed analysis of the 9 studies reporting case by case data showed that over 116 lesions, 50 were filled with more than 10 mL, 12 with more than 20 mL and 6 with more than 30 mL. Twenty-six of the 50 lesions filled with a volume greater than 10 mL were located in the pelvis (acetabulum was the most frequent location), and 24 in the long bones (femur was the most frequent location).

Technique of injection for volumes > 10 mL

Among the 17 studies that reported either a mean or a maximum volume superior to 10 mL, 7 briefly stated how such injection was achieved [11,14,24,29,31,34,35]. They all describe the use of additional needle(s) and cement(s) to complete the injection. The mean number of needles per site of injection was available for one of those 7 studies, with a mean value of 3.83 [35]. One study described precisely the technique used to inject more than 10 mL of cement [8]. In that article, the authors were injecting simultaneously different volumes of cement on 2 or 3 different bone trocars.

Lesion filling

Precise information (*i.e.*, not subjective) about the percentage of filling by cement was available in 3 studies (62 lesions) focusing on pelvic osteoplasties [8,9,14]. The percentage ranged from 54.8% to 64%, for a mean value of 56.8% using the overall weighted mean method. One other study reported the percentage of filling of the lesion as more than or less than 50%, with 70% of the lesions exhibiting a filling greater than 50% without further specification [6].

Outcomes

Pain palliation

Pain scores using a visual analogic scale (VAS) score could be extracted from 24 studies [6–11,17–22,24–26, 28,30,31,33,34,36–39]. Twenty-two of the 24 papers reported the VAS score as a 10 points scale [6,7, 9–11,18–22,24–26,28,30,31,33,34,36–39]; 2 studies used a 100 points scale which was turned into a 10 points scale for further evaluation [8,17]. One study mentioned the VAS score but without the possibility to differentiate the extra-spinal cases from the spinal ones and was therefore not included for analysis [32]. The 5 remaining studies did not report precisely the VAS score and only mentioned subjective evaluation of the pain [14,23,27,29,35]. The preoperative VAS scores ranged between 3.2 and 9.5 (n_p = 24). For the postoperative pain scores, we used the last time point available for evaluation. This time point could be extracted from 21 papers and ranged from 24 hours to one-year, with 14 articles reporting the last evaluation at one month or more (Table 3), and 10 articles at 3 months or more. The number of patients completing the last follow-up could not be precisely numbered. Overall, postoperative scores ranged from 0.4 to

Table 2 Volume of injected cement depending on bone lesion location.

References	Authors	No of lesions	Mean volume(mL)	Lesion filling
Pelvic cementoplasty				
[6]	Iannessi et al.	13	4.3	N.R
[21]	Basile et al.	6	3.5	N.R
[23]	Hierholzer et al.	4	17.75	N.R
[24]	Cotten et al.	12	15	N.R
[28]	Munk et al.	13	8.3	N.R
[29]	Weill et al.	18	7.8	N.R
[32]	Hoffmann et al.	6	8.7	N.R
[8]	Moser et al.	44	10.3	54.8%
[33]	Kelekis et al.	23	8	N.R
[34]	Wallace et al.	12	12	N.R
[14]	Kurup et al.	7	14	64%
[36]	Toyota et al.	12	7.5	N.R
[38]	Marcy et al.	18	6	N.R
Total		**188**	**9.1**	**56.1%**
Long bone cementoplasty				
[6]	Iannessi et al.	7	4.3	N.R
[23]	Hierholzer et al.	1	18	N.R
[28]	Munk et al.	1	5	N.R
[10]	Kim et al.	20	15.5	N.R
[11]	Kim et al.	43	19.1	N.R
[32]	Hoffmann et al.	3	6.7	N.R
[35]	He et al.	6	32.2	N.R
[36]	Toyota et al.	3	6	N.R
Total		**84**	**16.9**	**N.R**

Table 3 Clinical outcomes in studies reporting a follow-up of minimum one month.

References	Authors	Preoperative pain score	Postoperative pain score	Last time point for evaluation (Month)	Difference between pre-and post-operative pain scores	Statistically significant
[17]	Fares et al.	7.2	3.7	3	−3.5	Yes
[18]	Tian et al.	7.1	1.3	6	−5.8	Yes
[19]	Sun et al.	8.2	3	3	−5.2	Yes
[6]	Iannessi et al.	6.4	2	3	−4.1	Yes
[20]	Masala et al.	8.4	2.4	6	−6	Yes
[21]	Basile et al.	7.6	2.7	6	−4.9	Yes
[22]	Anselmetti et al.	9.1	2.4	12	−6.7	Yes
[10]	Kim et al.	7.2	2.8	1.5	−4.4	Yes
[26]	Maccauro et al.	8.6	5.1	12	−3.5	N.R
[28]	Munk et al.	7.9	3.6	1.5	−4.3	Yes
[31]	Deschamps et al.	6.1	1	1	−5.1	Yes
[37]	Wei et al.	7.4	1.2	6	−6.2	Yes
[38]	Marcy et al.	3.2	1.6	1	−1.6	N.R
[9]	Colman et al.	5.45	4	3	−1.45	N.R

N.R.: not reported.

5.6 ($n_p = 24$) [6—11,17—22,24—26,28,30,31,33,34,36—39]. Twenty-one papers over 24 reported a difference between the pre- and the post-interventional scores greater than two [6—8,10,11,17—22,25,26,28,30,31,33,34,36,37,39]. Thirteen studies reported a reduction of 5 points or more [6—8,10,18—20,22,30,31,34,35,37].

Symptomatic cement leakage

A total of 10 symptomatic leakages were numbered among the 761 lesions ($n_p = 30$), giving a rate of symptomatic leakage of 1.3% [6—11,14,17—39]. Nerve injury was the most frequent symptomatic leakage ($n = 4$; 0.6%).

Secondary fractures and secondary surgical procedures

Six studies did not clearly state if fracture assessment at the treated site was part of the follow-up [7,10,17,28,32,39]. Hence, 24 articles (626 lesions) were analyzed [6,8,9,11,14,18—27,29—31,33—38]. The length of follow-up was available for 22 of these 24 articles and ranged from 62 days to 26.4 months. A total of 14 fractures (2.2%) occurring at the treated site could be identified ($n_p = 24$), at an interval from the cementoplasty procedure ranging from 3 days to 7 months. Seven surgical interventions to fix the fracture were reported [22,27,36]. Additionally, two surgical extractions of cement leakages and 7 delayed acetabular interventions following percutaneous cementoplasty of the acetabulum (interval from the procedure available for only 3 procedures, ranging from 10 to 39 months) were reported [7—9,25,29].

Discussion

Percutaneous cementoplasty is an effective tool to alleviate the pain associated with extra-spinal bone metastases [6—8,10,11,17—22,25,26,28,30,31,33,34,36,37,39,40]. The technique has mostly been applied for acetabular lesions in the pelvis and in the femur for the long bones. The clinical benefit seems clear, as 21 over 24 studies reported a drop in pain score greater than 2 (which is considered as the threshold for significance), while the rate of symptomatic leakages was inferior to 2%. On the other hand, the review of the literature also demonstrates great heterogeneity in terms of clinical practice. Most of the procedures (84.2%) were performed by interventional radiologists, probably because of an easier access to computed tomography (CT) or cone bean CT that both offer high precision. Osteoplasty was performed as a stand-alone technique in the majority of lesions (60.1%), while in the remaining 40% it was combined with another technique such as thermal ablation (26.2%), implant devices (12.3%) or balloon kyphoplasty (1.4%) prior to cement injection.

The exact benefit of combined ablation and cementoplasty vs. cementoplasty alone cannot be assessed, especially for lesion limited to bone without extension to the surrounding soft tissue [41,42]. Thermal ablation certainly makes sense to alleviate the pain related to the invasion of the surrounding muscle in case of a large osteolytic metastasis [43,44]. This certainly explains that ablation was predominantly performed in association to cementoplasty for lesions located in the pelvic girdle, which frequently involve the surrounding soft tissue. Ablation prior to cement injection may also be indicated whenever local tumour control is indicated, as cementoplasty has little to no antitumoral effect and has been reported to transiently increase the level of the cancer circulating cells in the minutes following injection [45—48]. The predominance of monopolar RFA may seem strange in an era where bipolar RFA, cryoablation and even microwave ablation are more and more promoted for bone ablation [49—51]. The most likely explanation comes with the year with which the papers were issued, when monopolar RFA was the main if not the single available modality [52].

The use of implant devices in association with cementoplasty for lesions located in the long bones but not in the acetabulum makes sense on a biomechanical point of view: the high resistance of cement to compression load is adapted to ensure bone consolidation in the acetabulum, while the poor resistance of cement to shear, bending and torsion stresses makes it unsuitable as a stand-alone intervention for metaphyseal/diaphyseal lesions with a high risk of impending fractures [53—56]. Interestingly, all the lesions localized in the long bones and that were treated by surgeons underwent nail fixation and cementoplasty, while only 15% of the procedures in the long bones performed by interventional radiologists were associated with other implant devices, for which little to no biomechanical validation exists. It is possible that the procedures performed by orthopedics were more driven towards a mechanical stabilization than the one performed by interventional radiologists where pain control was the major concern. As demonstrated in another review, stand-alone cementoplasty in the long bones is effective to achieve pain alleviation and to improve mechanical function but fracture is the most frequent complication [57]. In any situations, mechanical stabilization should always be kept in mind when performing percutaneous cementoplasty in the long bones. In such area, the combination of fixation and cement can potentially improve the outcomes: nails/screws (depending on the location) stabilize the area while cement increases the anchorage of the device(s) and allows to optimize pain management related to the bony tumor infiltration [10,11,31,56,58—61].

The needle diameter used to perform cement injection ranged from 10- to 13-G in almost all procedures, which is similar to spinal cementoplasty [62]. However, one major difference with spine is the amount of cement that is injected. As shown in this review, the volume of cement is extremely variable. On average, the amount of injected cement was 8.8 mL, which is much higher than the mean value for a spinal vertebroplasty [13,62,63]. This is most likely explained by the greater volume of extra-spinal tumors compared to spinal lesions. This review also outlines that a significant number of procedures, especially in the long bones, required a volume greater than 10 mL. Such volume exceeds the usual volume of cement available in most of the commercially available cement kits. Surprisingly, only one paper over the 30 included for that review described in detail the technical approach to deal with such large volume [8]. Hence, in that paper focusing on pelvic osteoplasty, the authors injected simultaneously in 2 trocars with the idea to provide a coalescence of the different cement streams while injecting as much as possible [8]. In all other articles there was no or only brief description of the technique, which consisted in inserting an additional needle to inject more cement whenever required in most of procedures, but without further specification [11,14,24,29,31,34,35]. Besides, filling of the lesions is rarely reported, and is inferior to 60% in the few papers publishing the data [8,9,14]. There is no standardized volume of cement for extra-spinal cementoplasties and most authors advocate to fill the lesion and the surrounding cancellous bone as much as possible to provide optimal bone consolidation [14,64]. The impact of the degree of lesion filling on the mechanical outcome is however unclear in clinical practice. Optimal filling has always to be balanced with the risk of leakage. Although it is rare, cement leakage can be symptomatic and potentially worsen the symptomatology of the patient. The risk is supposed to be increased if the bone cortex is disrupted. The use of ablation, balloon kyphoplasty and/or high-viscosity bone cement could potentially reduce the risk of leakage but evidences are still lacking for extra-spinal procedures [14,65,66].

In conclusion, percutaneous extra-spinal cementopasty is predominantly performed as a stand-alone procedure and for lesions in the bony pelvis. It appears to be an effective tool to manage pain associated with malignant bone tumours. There is however a lack of standardization of the technique among the different publications.

Informed consent and patient details

The authors declare that this report does not contain any personal information that could lead to the identification of the patient(s).

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Author contributions

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Roberto Luigi Cazzato: conceptualization; data curation; formal analysis; investigation; methodology; resources; supervision; validation; visualization; roles/writing — original draft; writing — review and editing.

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The authors declare that they have no competing interest.

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