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MSK IO

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VERTEBRAL AUGMENTATION

- **FINANCIAL DISCLOSURES**

- FOCUSED CRYO: Advisory Board
- IMACTIS: Advisory Board
- ECO MEDICAL, NANJING: Proctor
- MEDTRONIC: Advisory Board, Proctor
- CANNON: Advisory Board
- IMPACKT: Advisory Board, Proctor

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VERTEBRAL AUGMENTATION

- Spine is most common site of osseous metastatic disease
  - 40% will develop spine metastases
  - Most will be lytic and involve the posterior vertebral body

- 53% with solid tumor bone mets suffer spinal skeletal related events (SRE)

- Greater than 25% occupancy of the vertebral body, and involvement of the vertebral endplate or all 3 columns should be considered for prophylactic or therapeutic decompressive and stabilization treatment

Hibberd CS et al Orthopedics 2018;41(1):e38-e45

VERTEBRAL AUGMENTATION

- Painful spinal metastases. Multiple pain generators.
- **Mechanical pain** – Caused by the VCF or pathological fracture. Spinal deformity, spine instability and a fracture line. (Goal is to stabilize through fixation or cement augmentation).
- **Biological pain** – Caused by Stretching/irritation of the periosteum: secondary to tumor growth, Tumor growth into surrounding nerves and tissues, or Osteoclast mediated bone resorption and associated release of neuro-stimulating cytokines.

Wallace AN, et al. AJNR Am J Neuroradiol. 2015.

VERTEBRAL AUGMENTATION

A

Scoring System		Treatment Strategy	Modified Treatment Strategy
Tokuhashi Score	15	Excisional Surgery	Excisional Surgery
	14		
	13		
	12		
	11	Palliative Surgery	
	10		
	9		
	8	Conservative Treatment	Palliative Surgery
	7		
	6		
	5		Conservative Treatment
	4		
	3		
	2		
	1		
	0		

B

Scoring System		Treatment Strategy	Modified Treatment Strategy
Tomita Score	2	En bloc Resection	En bloc Resection
	3		
	4	Intralesional Resection	Intralesional Resection
	5		
	6	Palliative Surgery	Palliative Surgery
	7		
	8	Supportive Care	
	9		Supportive Care
	10		

Aoude A, Amiot LP. A comparison of the modified Tokuhashi and Tomita scores in determining prognosis for patients afflicted with spinal metastasis. Can J Surg. 2014;57(3):188-93.

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VERTEBRAL AUGMENTATION

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Spine Instability Neoplastic Score (SINS)

Location	
Junctional (occiput-C2, C7–T2, T11–L1, L5–S1)	3
Mobile spine (C3–C6, L2–L4)	2
Semi-rigid (T3–T10)	1
Rigid (S2–S5)	0
Pain relief with recumbency and/or pain with movement/loading of the spine	
Yes	3
No (occasional pain but not mechanical)	1
Pain free lesion	0
Bone lesion	
Lytic	2
Mixed (lytic/blastic)	1
Blastic	0
Radiographic spinal alignment	
Subluxation/translation present	4
De novo deformity (kyphosis/scoliosis)	2
Normal alignment	0
Vertebral body collapse	
>50% collapse	3
<50% collapse	2
No collapse with >50% body involved	1
None of the above	0
Posterolateral involvement of the spinal elements (facet, pedicle or CV joint fracture or replacement with tumor)	
Bilateral	3
Unilateral	1
None of the above	0

Table 2
Spine Instability Neoplastic Score

Location	Points	Vertebral body collapse	Points
Junctional	3	>50% collapse	3
Mobile spine (C3–C6, L2–L4)	2	<50% collapse	2
Semirigid spine (T3–T10)	1	No collapse with >50% body involved	1
Rigid spine (S2–S5)	0	None of the above	0

Pain relief with recumbency/pain with movement or loading	Points	Bone lesion	Points
Yes	3	Lytic	2
No	2	Mixed	1
Pain-free lesion	0	Blastic	0

Radiographic spinal alignment	Points	Posterolateral involvement	Points
Subluxation/translation present	4	Bilateral	3
De novo deformity	2	Unilateral	1
Normal alignment	0	None	0

Note: Total score 0–6 points: stability; 7–12: indeterminate stability; 13–18: instability.

Fourney DR, Frangou EM, Ryken TC, et al. Spinal instability neoplastic score: an analysis of reliability and validity from the spine oncology study group. J Clin Oncol 2011;29:3072–7

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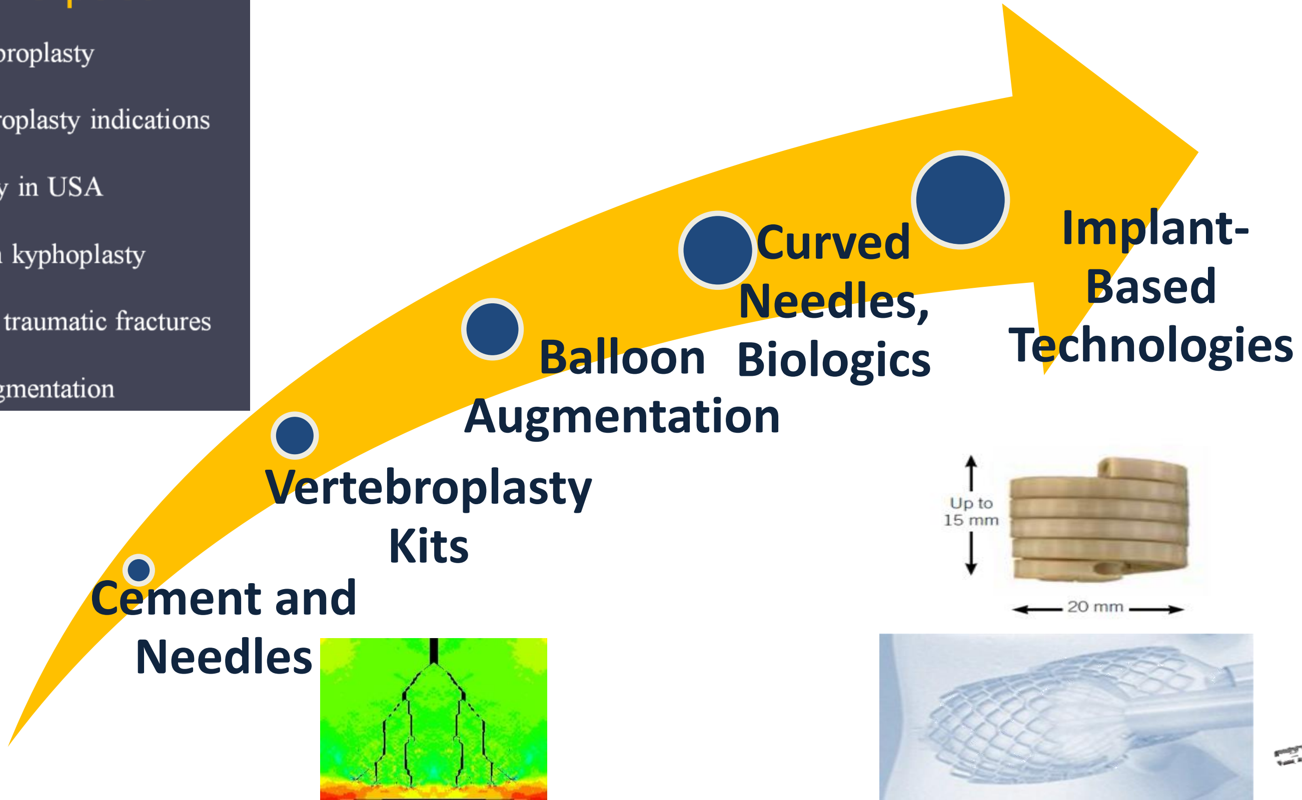
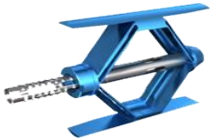
VERTEBRAL AUGMENTATION

A walk to the past.....

- 1984…Galibert-Deramond vertebroplasty
- 1989... Lapras-Duquesnel vertebroplasty indications
- 1997...Jensen-Dion vertebroplasty in USA
- 2001…Garfin-Reilley-Lieberman kyphoplasty
- 2002...Verlaan vertebroplasty for traumatic fractures
- 2014...percutaneous vertebral augmentation





VERTEBRAL AUGMENTATION

- Pathologic vs. Traumatic
- Osteoporotic
  - Thoracic vertebral fractures-no kyphotic deformity
  - Thoracic vertebral fractures-significant kyphotic deformity
  - Thoraco-lumbar junction fractures
  - Lumbar fractures- loss of, neutral, and hyper-lordotic
  - Sacral fractures—totally different mechanics
- Cancer related
  - Stable
  - Lytic, mixed
  - Impending or completed fracture
- Hemangioma
- Multiple Myeloma - Lymphoma

VERTEBRAL AUGMENTATION

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One size does not fit all

-Tailored Approach-

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VERTEBRAL AUGMENTATION

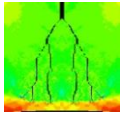
- Metastases
- Myeloma
- Lymphoma
- Leukemia

- Pain palliation

- Local tumor control

- Anterior stabilization

- Anti-tumoral effect



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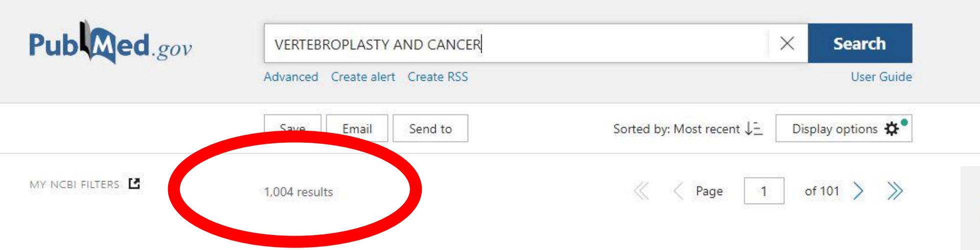

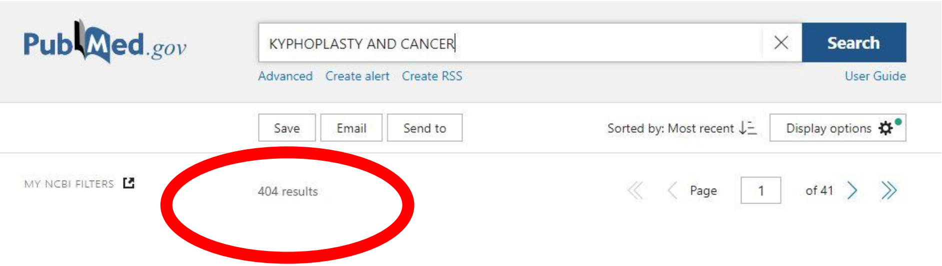

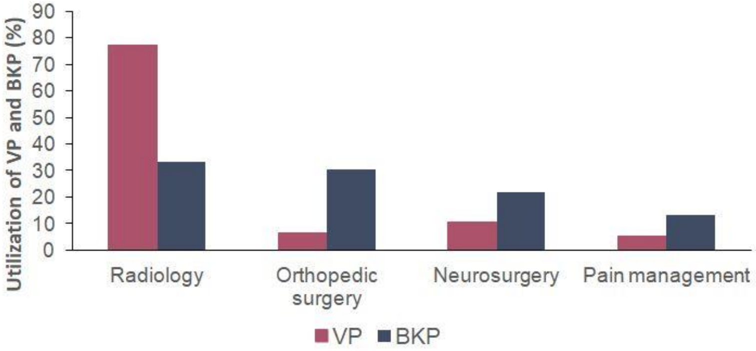

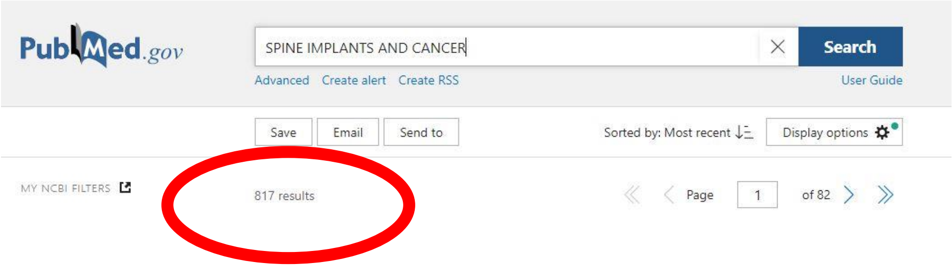

Hirsch JA et al. J Neurointervent Surg 2016;8:1299-304

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INTERNATIONAL ACCREDITATION SYSTEM FOR INTERVENTIONAL ONCOLOGY SERVICES

VERTEBRAL AUGMENTATION

Cardiovasc Intervent Radiol (2017) 40:1815–1823
DOI 10.1007/s00270-017-1779-x

CIRSE CrossMark

REVIEW

Percutaneous Vertebroplasty and Kyphoplasty: Current Status, New Developments and Old Controversies

Dimitrios K. Filippiadis[1] · Stefano Marcia[2] · Salvatore Masala[3] · Frederic Deschamps[4] · Alexis Kelekis[1]

performing vertebral augmentation may be less than from not performing the procedure.

As far as cancer-related fractures are concerned, economic analyses report that the use of kyphoplasty or vertebroplasty may be a cost-effective strategy at commonly accepted willingness-to-pay thresholds [64].

Percutaneous Vertebroplasty or Balloon Kyphoplasty?

An analysis of the Medicare population concludes that BKP has a statistically significant higher survival rate (of 62.8% as compared to 57.3% for PVP) and a 23% lower mortality rate than that for vertebroplasty patients ($p < 0.001$) [58]. Another analysis of the Medicare Provider and Review File database concludes that BKP tends to have a more striking association with survival than vertebroplasty does, but it is costly and may have a higher rate of subsequent vertebral compression fracture [42]. A UK cost-effectiveness analysis concludes that BKP may be a cost-effective strategy for the treatment of patients

It is evident that throughout the literature there is no clearly proven superiority of one technique over the other; all the aforementioned provocative results and conclusions could easily be related to selection biases. Ideally, a prospective randomized direct comparison of the two methods for the treatment of vertebral compression fractures in similar patient groups would provide the answers. However, the question still remains: How easy is it to design and perform such a study?

Randomized Trials

Up until 2009, there was a great enthusiasm for vertebroplasty mainly driven by the outcomes reported in the everyday clinical practice and by meta-analyses of large observational and retrospective series showing pain reduction, mobility and life quality improvement [72]. In this year, two placebo-controlled vertebroplasty randomized trials were published in the New England Journal of Medicine (NEJM) supporting that pain and pain-related disability improvement in patients with osteoporotic

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Cardiovasc Intervent Radiol (2017) 40:331–342
DOI 10.1007/s00270-017-1574-8

CIRSE

CIRSE STANDARDS OF PRACTICE GUIDELINES

CIRSE Guidelines on Percutaneous Vertebral Augmentation

Georgia Tsoumakidou[1] · Chow Wei Too[1] · Guillaume Koch[1] · Jean Caudrelier[1] · Roberto Luigi Cazzato[1] · Julien Garnon[1] · Afshin Gangi[1]

Table 1 Table 1 reports response rates to PVP according to different parameters and in different pathologies

Criteria	Success Rate
1. Pain relief	
Acute osteoporotic fracture	90% [16, 72–77]
Chronic osteoporotic fractures	80–100% [36, 39]
Malignant fractures	60–85% [25, 27, 73, 78–80]
Hemangiomas	80–100% [73, 81–83]
2. Increased mobility	
Acute osteoporotic fracture	84–93% [16, 75]
Chronic osteoporotic fracture	50–88% [36, 39]
3. Reduced requirement for analgesics	91% [16, 75]

- Cement leakage
- Infection
- Fracture of ribs, posterior elements or pedicle
- Risk of collapse of the adjacent vertebral body
- Allergic reaction
- Bleeding from the puncture site

Complications

Published data have placed the symptomatic complication rates of PVP of osteoporotic at 2.2–3.9% [84, 85], and in malignant fractures at <11.5% [71]. Centres planning on starting a PVP programme should aim at keeping their complication rates below the published rates. We recommend a threshold of 2% for all symptomatic complications for PVP performed for osteoporotic indications, and 10% for malignant indications [86].

VERTEBRAL AUGMENTATION

Wang *et al.*
World Journal of Surgical Oncology (2022) 20:112
https://doi.org/10.1186/s12957-022-02583-5

World Journal of Surgical Oncology

RESEARCH Open Access

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Cement leakage in percutaneous vertebroplasty for spinal metastases: a retrospective study of risk factors and clinical outcomes

Table 3 Multivariate logistic analysis for the occurrence of cement leakage

Features	OR	(95%CI)	*P*
Tomita classification	2.060	1.124–3.776	**0.019**
Post-OP chemo/radiotherapy	2.679	0.822–8.734	0.102
Vertebra level	0.724	0.232–2.253	0.577
Posterior wall destruction	19.706	3.653–106.297	**0.001**
Injected laterality	0.369	0.118–1.151	0.086
Injected volume	0.698	0.476–1.024	0.066

Table 4 Univariate analysis for the occurrence of cement leakage in the spinal canal

Features	Other = 95	Spinal canal = 18	*P*
Previous chemo/radio-therapy			0.092
No	49 (51.6%)	9 (50.0%)	
Yes	46 (48.4%)	9 (50.0%)	
Tomita classification			0.739
Slow	25 (26.3%)	4 (22.2%)	
Moderate	10 (10.5%)	3 (16.7%)	
Rapid	60 (63.2%)	11 (61.1%)	
Post-OP chemo/radio-therapy			0.359
No	22 (23.2%)	6 (33.3%)	
Yes	73 (76.8%)	12 (66.7%)	
Other metastasis			0.736
No	62 (65.3%)	11 (61.1%)	
Yes	33 (34.7%)	7 (38.9%)	
Vertebra level			0.789
Thoracic	39 (41.1%)	8 (44.4%)	
Lumbar	56 (58.9%)	10 (55.6%)	
Collapse			0.962
No	58 (61.7%)	11 (61.1%)	
Yes	36 (38.3%)	7 (38.9%)	
Posterior wall destruction			**0.001**
No	15 (15.8%)	9 (50.0%)	
Yes	80 (84.2%)	9 (50.0%)	
Injected laterality			**0.019**
Single	38 (40.0%)	2 (11.1%)	
Bilateral	57 (60.0%)	16 (88.9%)	
Injected volume	4.50 (3.00–6.00)	6.00 (4.00–7.12)	**0.020**

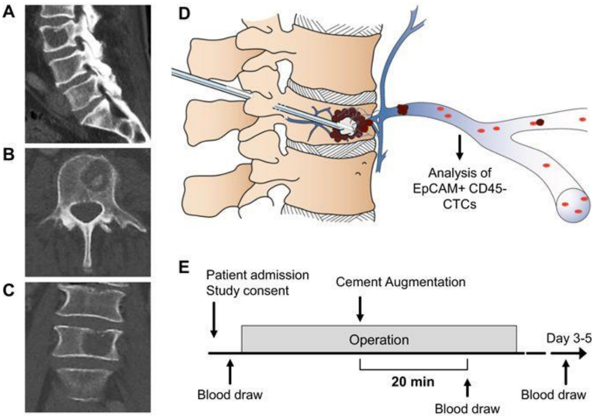
VERTEBRAL AUGMENTATION

SCIENTIFIC REPORTS

Sci Rep. 2017 Aug 3;7(1):7196. doi: 10.1038/s41598-017-07649-z.

Circulating Tumour Cell Release after Cement Augmentation of Vertebral Metastases.

Mohme M[1], Riethdorf S[2], Dreimann M[3], Werner S[2], Maire CL[4], Joosse SA[2], Bludau F[5], Mueller V[6], Neves RPL[7], Stoecklein NH[7], Lamszus K[4], Westphal M[4], Pantel K[2], Wikman H[2], Eicker SO[4].

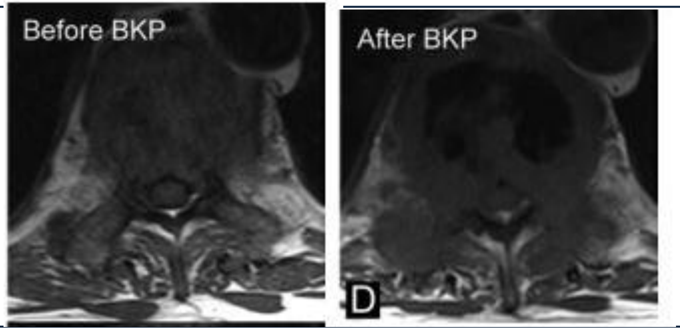


Cement augmentation via percutaneous vertebroplasty or kyphoplasty for treatment of spinal metastasis is a well-established treatment option. We assessed whether elevated intrametastatic pressure during cement augmentation results in an increased dissemination of tumour cells into the vascular circulation. We prospectively collected blood from patients with osteolytic spinal column metastases and analysed the prevalence of circulating tumour cells (CTCs) at three time-points: preoperatively, 20 minutes after cement augmentation, and 3–5 days postoperatively. Enrolling 21 patients, including 13 breast- (61.9%), 5 lung- (23.8%), and one (4.8%) colorectal-, renal-, and prostate-carcinoma patient each, we demonstrate a significant 1.8-fold increase of EpCAM+/K+ CTCs in samples taken 20 minutes post-cement augmentation ($P < 0.0001$). Despite increased mechanical CTC dissemination due to cement augmentation, follow-up blood draws demonstrated that no long-term increase of CTCs was present. Array-CGH analysis revealed a specific profile of the CTC collected 20 minutes after cement augmentation. This is the first study to report that peripheral CTCs are temporarily increased due to vertebral cement augmentation procedures. Our findings provide a rationale for the development of new prophylactic strategies to reduce the increased release of CTC after cement augmentation of osteolytic spinal metastases.

VERTEBRAL AUGMENTATION

Tumor extravasation following a cement augmentation procedure for vertebral compression fracture in metastatic spinal disease

2-Case patient study involving the phonemonial of 'tumor extravasation' In this paper, the authors describe for the first time an iatrogenic complication secondary to BKP that we characterize as **"tumor extravasation."**



- **Conclusions:** Accordingly, the authors advise caution in using BKP when significant epidural tumor is present.

Cruz JP, Sahgal A. *J Neurosurg: Spine / June 6, 2014*

VERTEBRAL AUGMENTATION

Cardiovasc Intervent Radiol. 2013 Feb;36(1):183-91. doi: 10.1007/s00270-012-0379-z. Epub 2012 Jun 27.

Clinical outcome and safety of multilevel vertebroplasty: clinical experience and results.

Mailli L[1], Filippiadis DK, Brountzos EN, Alexopoulou E, Kelekis N, Kelekis A.

Table 1 Sample characteristics

Characteristics		N	%
Sex	Male	31	23.8
	Female	99	76.2
Cause	Osteoporosis	77	59.2
	Malignancy	38	29.2
	Hemangioma	15	11.5
No. of treated vertebrae	1–3	94	72.3
	>3	36	27.7
Transpedicular approach	Unilateral	81	86.2
	Bilateral	13	13.8
Leakage	No	86	66.1
	Yes	25	33.8

Table 2 Changes in G-BPI score during the 2-year follow-up period*

G-BPI	Baseline	Day 1	Year 1	Year 2	Change[a]	Mean change (%)	p^b	p^c
Total	7.9 ± 1.2	2.1 ± 1.5	2.0 ± 1.5	2.0 ± 1.5	−5.9 ± 1.9	−74.7	<0.001	
Cause								
Osteoporotic	8.1 ± 0.8	2.2 ± 1.4	2.1 ± 1.3	2.1 ± 1.4	−6.0 ± 1.6	−74.1	<0.001	0.560
Malignancy	7.7 ± 1.8	2.0 ± 1.6	1.9 ± 1.7	1.9 ± 1.7	−5.8 ± 1.6	−75.3	<0.001	
Hemangioma	7.6 ± 1.1	2.2 ± 2	2.1 ± 1.7	2.0 ± 1.6	−5.6 ± 1.0	−73.7	0.001	
p^d	0.137	0.599	0.362	0.326				
No. of treated vertebrae								
1–3	7.9 ± 1.1	2.1 ± 1.6	2.0 ± 1.5	2.0 ± 1.5	−5.9 ± 1.9	−74.7	<0.001	0.425
>3	8.1 ± 1.3	2.2 ± 1.3	2.0 ± 1.5	2.1 ± 1.6	−6.0 ± 1.8	−74.1	<0.001	
p^d	0.656	0.294	0.694	0.531				
Transpedicular approach								
Unilateral	8.0 ± 1.1	2.1 ± 1.6	2.0 ± 1.5	1.9 ± 1.5	−6.1 ± 1.8	−76.3	<0.001	0.471
Bilateral	7.6 ± 0.9	2.1 ± 1.0	2.1 ± 0.9	2.0 ± 0.8	−5.6 ± 1.0	−73.7	0.001	
p^d	0.169	0.522	0.357	0.335				
Leakage								
No	8.0 ± 1.1	2.1 ± 1.5	1.9 ± 1.3	2.0 ± 1.4	−6.0 ± 1.7	−75.0	<0.001	0.685
Yes	7.8 ± 1.4	2.1 ± 1.6	2.2 ± 1.8	2.1 ± 1.8	−5.7 ± 2.1	−73.1	<0.001	
p^d	0.639	0.554	0.801	0.772				

CONCLUSION: PVP is an efficient and safe technique for symptomatic vertebral fractures independently of the vertebrae number treated per session.

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Safety and Efficacy of **Multilevel** Thoracolumbar **Vertebroplasty** in the Simultaneous Treatment of Six or More Pathologic Compression Fractures.

Moulin B, Tselikas L, Gravel G, Al Ahmar M, Delpla A, Yevich S, Hakime A, Territehau C, De Baere T, Deschamps F.

J Vasc Interv Radiol. 2020 Oct;31(10):1683-1689.e1. doi: 10.1016/j.jvir.2020.03.011. Epub 2020 Sep 10.

Table 4. Published Retrospective Series of Multilevel Vertebroplasty for Pain Palliation in Spinal Metastases (8,21,22,23)

Study, Year	Pts./ Sessions	Vertebrae	Mean Levels by Session (Range)	Etiology	Bone-Targeted Therapy	RT	NRS/VAS Preoperative	NRS/VAS Postoperative	NRS/VAS Decrease (%)	Opioid Decrease (%)	General Status Improvement (%)
Mailli et al, 2012 (8)	14/14	92	6.6 (6–8)	Metastasis or osteoporosis	–	–	8.1 ± 1.3	2.2 ± 1.3	−73%	–	ECOG +66%
Zhang et al, 2017 (21)	60/36	284	4.7(4–8)	Metastasis (including myeloma)	–	–	7.8 ± 1.6	2.1 ± 1.2	−73%	–	KPS +20%
Tran Thang et al, 2008 (22)	28/34	117	3.4 (1–9)	Metastasis (exclusively myeloma)	–	–	7.48	2.1	−72%	−70%	ECOG +55%
Zhang et al, 2013 (23)	43/43	126	2.9 (1–6)	Metastasis (exclusively breast cancer)	Bisphosphonates	–	7.6 ± 1.9	2 ± 1.5	−74%	–	KPS +23%
Present series, 2019	50/50	397	7.9 (6–13)	Metastasis (including myeloma)	Bisphosphonates or denosumab	Yes	5.0 ± 1.8	1.7 ± 1.4	−66%	−39%	–

Note–There were no major complications in any study.
ECOG = Eastern Cooperative Oncology Group; KPS = Karnofsky performance status; NRS = numeric rating scale; RT = radiation therapy; VAS = visual analog scale.

Table 1. Patient Demographic Data and Disease Characteristics (N = 50)

Characteristic	Value
Mean age (y) ± standard deviation	66 ± 10
Sex	
Male	26 (52)
Female	24 (48)
Primitive tumor location	
Multiple myeloma	13 (26)
Breast	12 (24)
Prostate	6 (12)
Lung	6 (12)
Miscellaneous	13 (26)
Vertebroplasty decision	
Pain release	40 (80)
Opioid consumption decrease	10 (20)
Number of levels treated	
6	13 (26)
7	13 (26)
8	8 (16)
9	7 (14)
10	3 (6)
11	2 (4)
12	3 (6)
13	1 (2)
Preprocedure NRS pain intensity	
Mild (0 ≤ NRS score ≤ 2)	10 (20)
Moderate (3 ≤ NRS score ≤ 5)	18 (36)
Severe (6 ≤ NRS score ≤ 10)	22 (44)
Preprocedural radiation therapy	
Yes	19 (38)
No	31 (62)

Note–Values in parentheses are percentages.
NRS = numeric rating scale

Conclusions: Multilevel vertebroplasty for ≥ 6 pathologic compression fractures is safe and provides significant palliative benefit when performed simultaneously.

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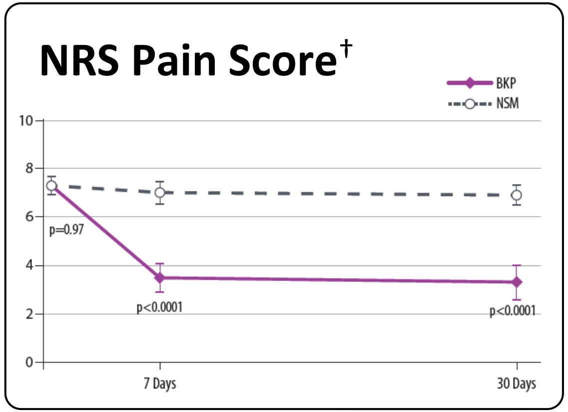
CAncer Patient Fracture Evaluation (CAFE) Study

- Balloon Kyphoplasty versus Non-surgical Fracture Management for Treatment of Painful Vertebral Body Compression Fractures in Patients with Cancer: A Multicentre, Randomised Controlled Trial

Berenson *et al*. 2011;12:225-35. LANCET 2011

	BKP n = 70	NSM (control) n = 64
Number patients evaluable	68	61
Number of patients not evaluable**	2	3
Patient age, mean (range)	64.8 (38-88)	63.0 (40-83)
Estimated Fx age, months, median	3.4	3.5
Underlying etiology		
Multiple myeloma	22 (32%)	27 (44%)
Breast cancer	16 (24%)	12 (20%)
Lung cancer	7 (10%)	4 (6.6%)
Prostate cancer	4 (5.9%)	4 (6.6%)
Other †	19 (28%)	14 (23%)
Bisphosphonate use	30 (44%)	33 (54%)
Steroid use	20 (29%)	25 (41%)
Fractures per patient		
1	24 (35%)	27 (44%)
2	18 (26%)	20 (33%)
3	26 (38%)	14 (23%)



		BKP	NSM (control)
Back-specific Function	RDQ	Improved *§‡	No Change
QOL	Karnofsky	Improved *§‡	No Change
	SF-36 PCS	Improved *§‡	No Change
	SF-36 MCS	Improved *‡	No Change
Activity	Limited Activity Days	Improved *‡	No Change
	Bed Rest Days	Improved *‡	No Change
Back Pain	NRS	Improved *§‡	Minimal Change **
	Analgesic Use	96% @ Baseline dropped to 60% ‡	84% @ Baseline dropped to 72%

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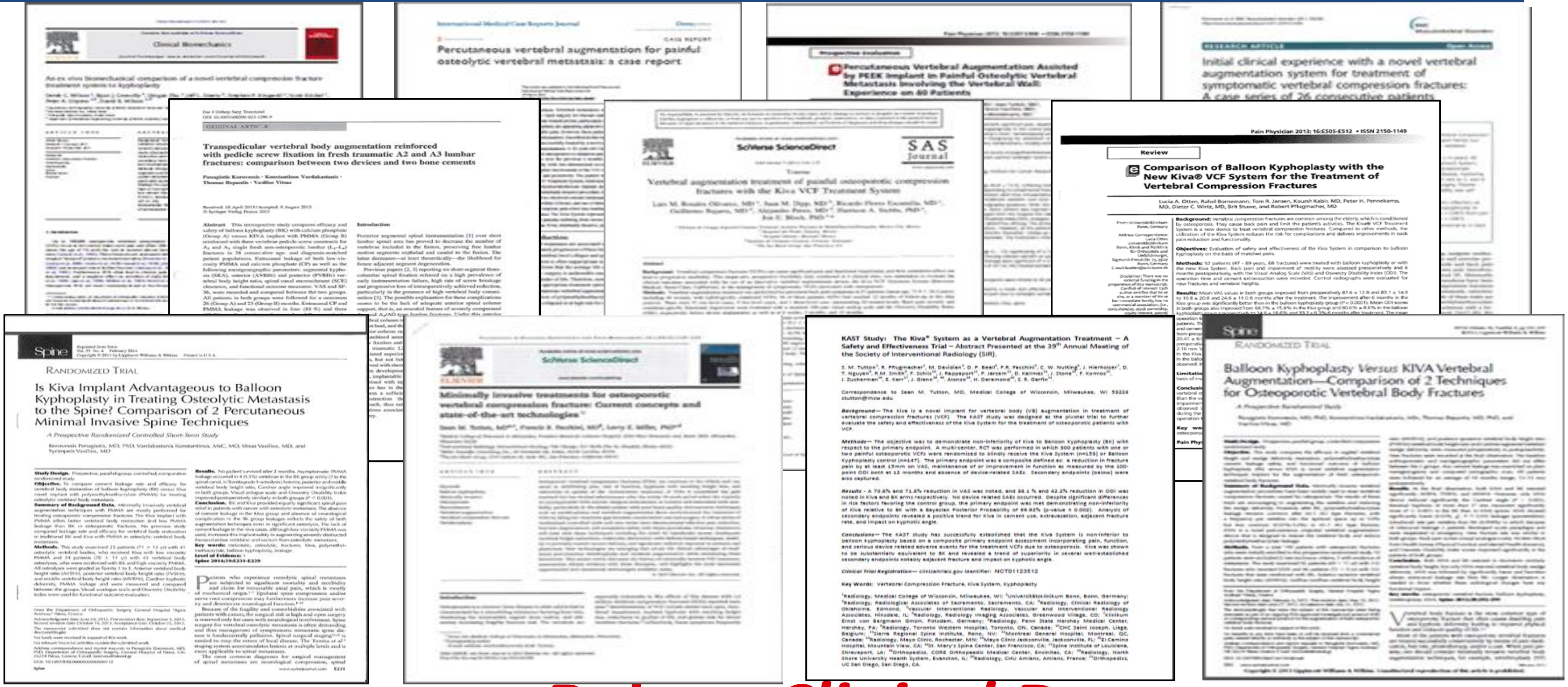


Robust Clinical Data

VERTEBRAL AUGMENTATION

Percutaneous Vertebral Augmentation Assisted by PEEK Implant in Painful Osteolytic Vertebral Metastasis Involving the Vertebral Wall: Experience on 40 Patients

Prospective study of 40 patients suffering from a painful spine malignancy with vertebral wall involvement not responding to conventional therapies

Vertebral augmentation with Kiva intravertebral implant for pain palliation

Median pre-treatment VAS of 10 (range 6 – 10) significantly (P < 0.001) dropped to one (range 0 – 3), with all patients achieving a clinically relevant benefit on pain at one month

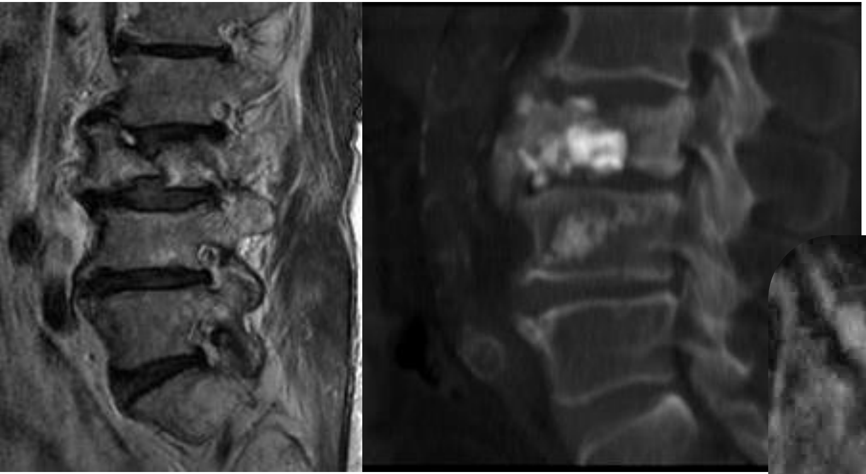
Conclusions: The Kiva System potentially represents a novel and effective minimally invasive treatment option for patients suffering from severe pain due to osteolytic vertebral metastases.

Anselmetti et al Pain Physician 2013; 16:E397-E404

1837 2017 YEARS
HELLENIC REPUBLIC
National and Kapodistrian University of Athens

VERTEBRAL AUGMENTATION

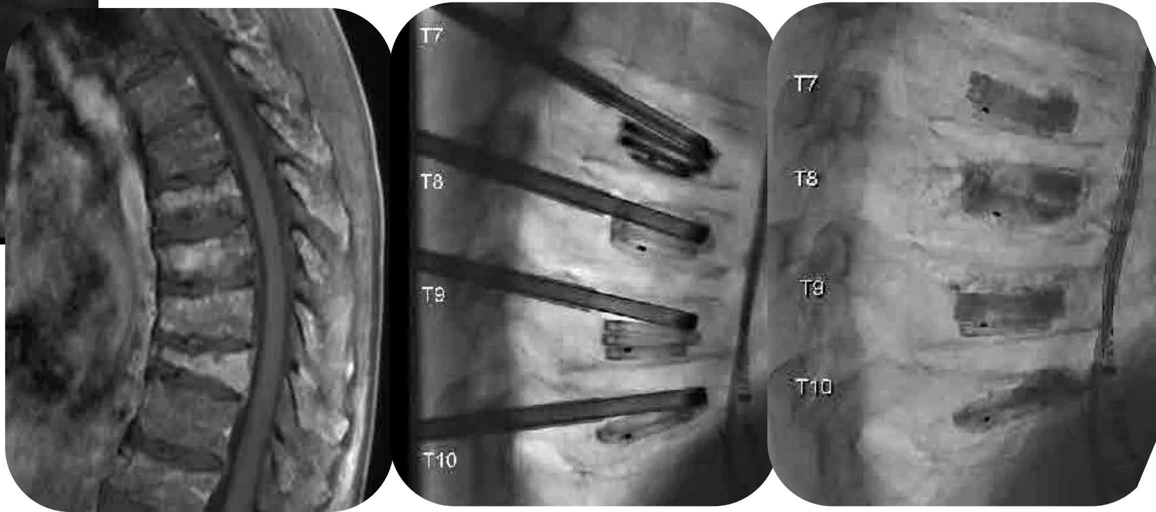
PEEK IMPLANT



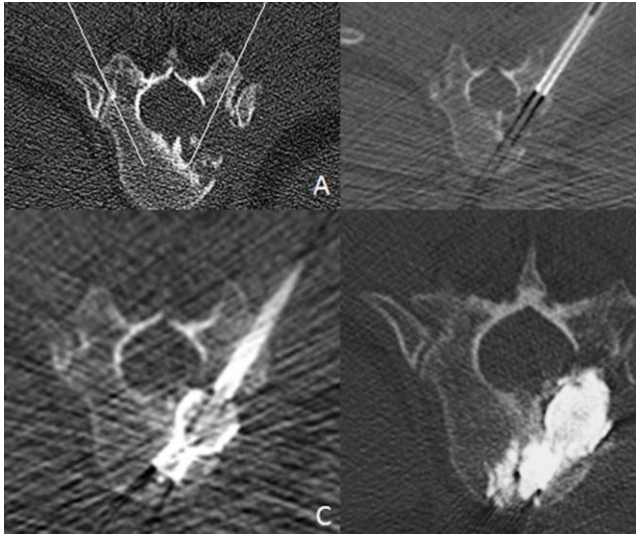
Bladder Ca

Multiple Myeloma

Images courtesy Sean Tutton, M.D., FSIR



VERTEBRAL AUGMENTATION



ECR 2015 / C-1719

Vertebral body stenting and cement augmentation to restore structural stability in extreme spinal osteolysis,

L. Danieli[1], E. Raz[2], M. Reinert[3], G. Pesce[4], G. Bonaldi[5], A. Cianfoni[3]; [1]Rome/IT, [2]New York, NY/US, [3]Lugano/CH, [4]Bellinzona/IT, [5]Bergamo/IT

VERTEBRAL AUGMENTATION

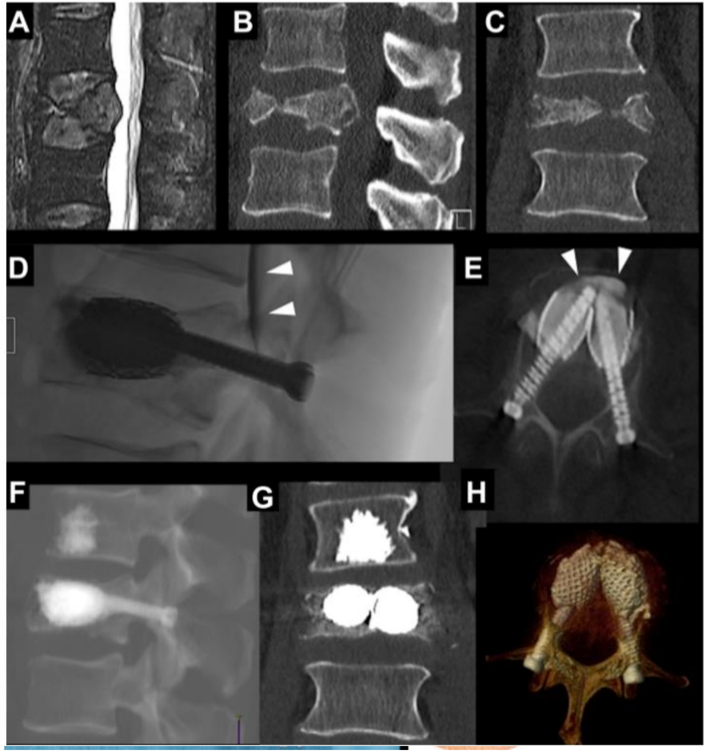
J NeuroIntervent Surg 2018;0:1–7. doi:10.1136/neurintsurg-2018-014481

Spine

ORIGINAL RESEARCH

Stent-screw-assisted internal fixation: the SAIF technique to augment severe osteoporotic and neoplastic vertebral body fractures

Alessandro Cianfoni,[1,2] Daniela Distefano,[1] Maurizio Isalberti,[1] Michael Reinert,[3,4] Pietro Scarone,[4] Dominique Kuhlen,[4] Joshua A Hirsch,[5] Giuseppe Bonaldi[6]



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VERTEBRAL AUGMENTATION

ATTIKON

IASIOS

	Rose et al[35] MSKCC (2009)	Boehling et al[36] MDACC (2012)	Cunha et al[34] UofT (2012)
Number of patients	71 spinal segments in 62 patients	123 spinal segments in 93 patients	167 spinal segments in 90 patients
Median follow-up (months)	13	14·9	7·4
SBRT median or total dose/ fraction	Median 24 Gy (range 18–24)/1	Total 18 Gy/1 (34%), 27 Gy/3 (49%), 30 Gy/5 (17%)	Total 20–24 Gy/1 (19%), 8–18 Gy/1 (3%), 18–24 Gy/2 (25%), 20–27 Gy/3 (35%), 30 Gy/4 (3%), 25–35 Gy/5 (15%)
Tumour characteristics	65% osteolytic, 18% osteosclerotic, 17% mixed	58% osteolytic, 21% osteosclerotic, 21% mixed	48% osteolytic, 26% osteosclerotic, 26% mixed
Tumour location	9% cervical, 66% thoracic, 25% lumbar-sacral	4% cervical, 54% thoracic, 42% lumbar-sacral	18% cervical, 46% thoracic, 36% lumbar-sacral
Incidence of VCF (%)	39%	20%	11%
Time to VCF (months)	Median 25	Median 3	Median 2, mean 3·3, 1-year FFP 87·3%
Salvage interventions (%)	3/27 (11%); 2 surgery, 1 cement [illegible]	10/25 (40%); 10 cement [illegible]	9/19 (47%); 3 surgery, 6 cement [illegible]
Significant predictors of VCF on multivariate proportional hazard analysis	Osteolytic tumour (HR 3·8, 95% CI 1·2–11·4); 41–60% vertebral body involvement (HR 3·9, 95% CI 1·1–14·2)	Age >55 years (HR 5·67, 95% CI 2·13–19·69); pre-SBRT VCF (HR 4·12, 95% CI 1·82–9·21); osteolytic tumour (HR 2·76, 95% CI 1·2–7·1)	Kyphosis/scoliosis (HR 11·1, 95% CI 3·0–41·7); osteolytic tumour (HR 12·2, 95% CI 2·6–58·8); lung histology (HR 4·3, 95% CI 1·2–16); liver histology (HR 34, 95% CI 0·024–192·5), ≥20 Gy dose per fraction (HR 6·82, 95% CI 1·83–25·42)

MSKCC=Memorial Sloan-Kettering Cancer Center. MDACC=MD Anderson Cancer Center. UofT=University of Toronto. SBRT=stereotactic body radiotherapy. VCF=vertebral compression fracture. FFP=fracture-free progression. HR=hazard ratio.

Table: Summary of studies reporting on VCF after spine stereotactic body radiotherapy

65% of fractures occurred in the first 4 months

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VERTEBRAL AUGMENTATION

The Use of Vertebral Augmentation and External Beam Radiation Therapy in the Multimodal Management of Malignant Vertebral Compression Fractures

retrospective analysis of 201 cases of patients with cancer and MCFs who received both external beam radiation therapy (EBRT) and VA

in only 4% of cases did patients report worsening of their fracture-related pain post-procedure.

there was no difference in pain outcomes with regard to sequencing of EBRT and VA

Conclusions: The majority of patients with MCFs have excellent palliation with this approach.

In patients who receive both EBRT and VA, the sequence in which they are given does not affect pain improvement outcomes.

Hirsch et al Pain Physician 2011; 14:447-458

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VERTEBRAL AUGMENTATION

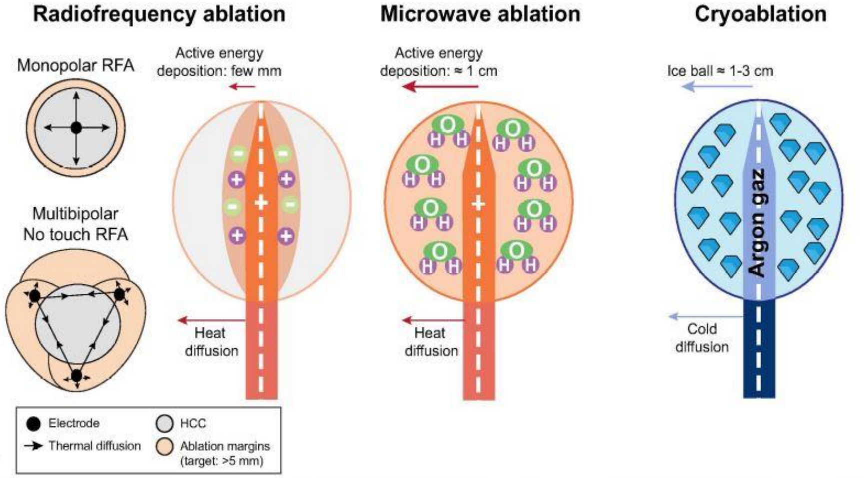
Interaction of radiation therapy and radiofrequency kyphoplasty in the treatment of myeloma patients

86 myeloma patients with VCF were treated with RF+KP followed by radiation therapy (RFK group) or vice versa (RT group)
Both groups achieved comparable outcomes in height restoration, pain reduction and impact of functional Impairment but:
More cement leakages and additional fractures were noted in the RT group

Conclusions: With regard to higher rates of bone cement extrusion and additional fractures we recommend to perform radiation therapy before radiofrequency kyphoplasty though

Bornemann et al Technol Health Care . 2017;25(3):567-575

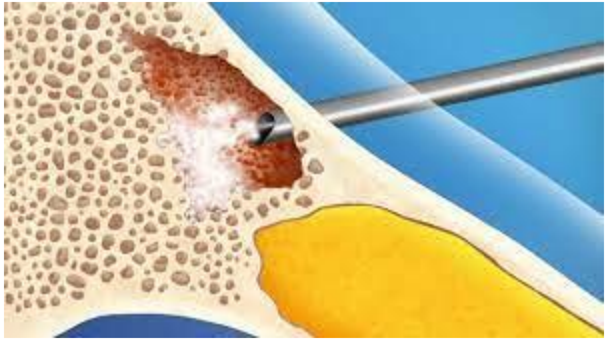
VERTEBRAL AUGMENTATION



Radiofrequency ablation: Advantages	Radiofrequency ablation: Limitations	Microwave ablation: Advantages	Microwave ablation: Limitations	Cryoablation: Advantages	Cryoablation: Limitations
Well evaluated treatment (reference) Multibipolar mode: increases volume and predicibility (margin) of ablation zones	Thermal injury of adjacent structure Heat sink effect (near major vessels) Multibipolar mode is less sensitive to heat sink effect	Higher and faster temperature picks reached than with RFA (less sensitive to heat sink effect than monopolar RFA)	No reliable end point to set the amount of energy deposition	Easy monitoring with imaging of ice ball progression	Cryoshock w device Limited clinic available with devices

Journal of Hepatology Volume 68 Issue 4 Pages 783-797 (April 2018) DOI: 10.1016/j.jhep.2017.10.004

ALWAYS COMBINE WITH CEMENT INJECTION
AVOID PATHOLOGIC FRACTURES



VERTEBRAL AUGMENTATION

Percutaneous bone tumor management

(PMMA) provides pain relief and bone strengthening in patients with malignant bone tumors.

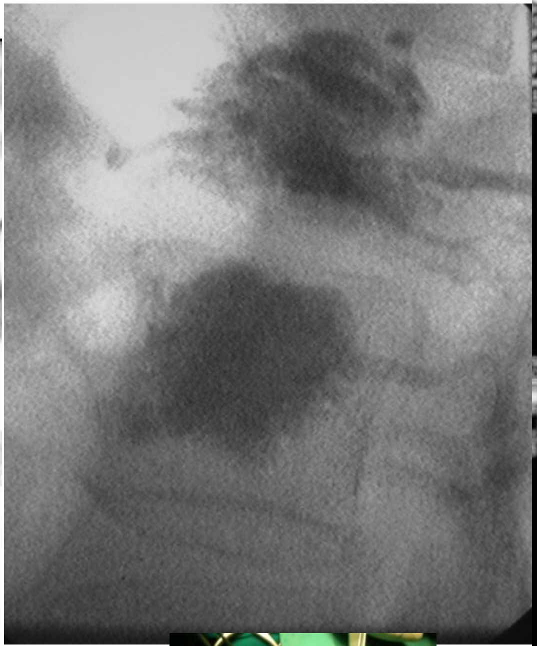
PMMA is suitable for treatment of fractures involving weight-bearing bones, such as vertebral body.

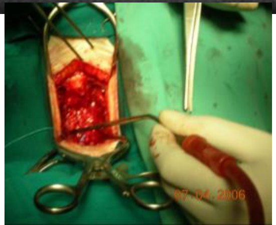
This procedure is performed in a palliative intent and **does not stop tumor progression**; thus, it should be considered as a complement, not a replacement, to other treatment modalities for cancer

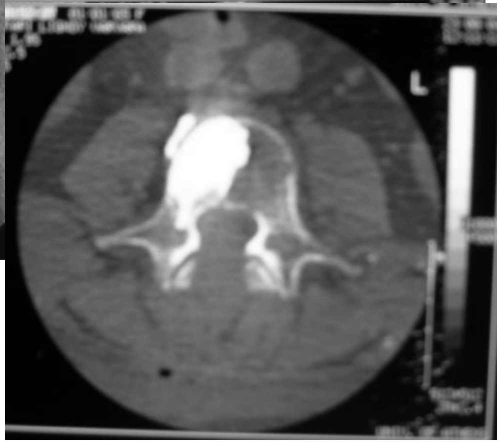
Gangi A., BuyX. Semin Intervent Radiol. 2010;27(2):124-36.

VERTEBRAL AUGMENTATION

Breast Meta







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VERTEBRAL AUGMENTATION

VERTEBRAL AUGMENTATION

Contents lists available at ScienceDirect
Journal of Bone Oncology
journal homepage: www.elsevier.com/locate/jbo

Review article

Future directions for bone metastasis research – highlights from the 2015 bone and the Oncologist new updates conference (BONUS)

Ricardo Fernandes [a], Peter Siegel [b], Svetlana Komarova [b,c], John Hilton [a,d], Christina Addison [d], Mohammed F K Ibrahim [a], Joel Werier [d,e], Kristopher Dennis [f], Gurmit Singh [g], Eitan Amir [h], Virginia Jarvis [a], Urban Emmenegger [i], Sasha Mazzarello [d], Mark Clemons [a,d,*]

evaluate patient prognosis in this setting could be invaluable. Minimally invasive techniques such as radiofrequency ablation, percutaneous cryoplasty, cementoplasty, and vertebroplasty can be effective in patients who are poor surgical candidates or who have a specific lesion that can be addressed by these techniques. Surgical stabilization is

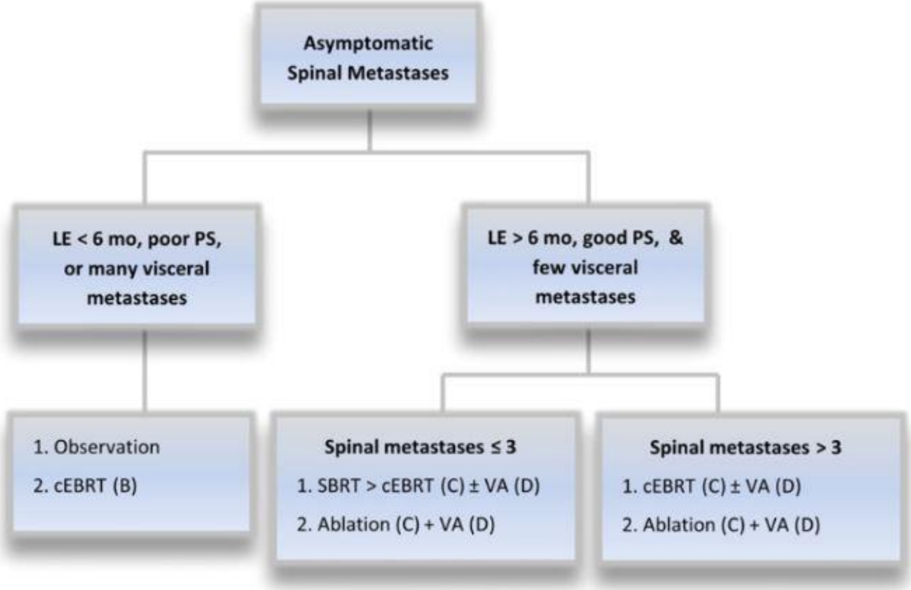
European Society of Medical Oncology (ESMO)

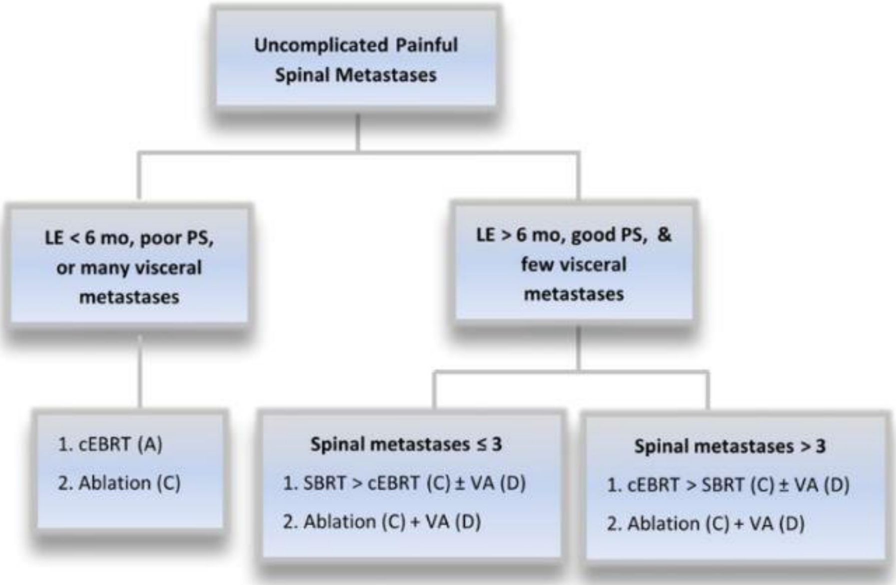
Table 1. Non-tumour-related causes of pain in cancer patients

Acute procedural pain	Iatrogenic pain causes	Comorbidity-related pain	Pain in cancer survivors
Adjuvant setting			
– Diagnostic intervention – Lumbar puncture ± headache – Transthoracic needle biopsy – Endoscopy ± visceral dilatation – Bone marrow aspiration/biopsy – Blood sampling – Central line position – Arterial line injections – Medication of skin ulcers – Myelography and lumbar puncture – Thoracentesis	– Surgery – Chemotherapy – Hormonal therapy – Targeted therapy – Osteonecrosis of the jaw – RT – Steroids (pain due to skin lesions, peripheral neuropathy, mucositis, aseptic femoral head necrosis, infections)	– Cardiovascular – Pulmonary – Diabetic neuropathy – Vasomotor headache – Fibromyalgia – May be worsened by anticancer treatments and/or cancer-related pain – Postherpetic neuralgia – Acute thrombosis pain	– Follow-up procedures – Persisting postsurgical pain – Persisting anticancer drug-related pain – Persisting RT-related pain – Postherpetic neuralgia
Neo-adjuvant setting			
– As adjuvant setting plus diagnostic and prognostic tissue biopsy	– As adjuvant setting without surgery-related pain	– As adjuvant setting	– As adjuvant setting
Locally advanced setting			
– As adjuvant setting plus pleurodesis, tumour embolisation, suprapubic catheterisation and nephrostomy insertion	– As adjuvant setting plus cryosurgery, thermal ablation, TACE, spinal/epidural injec- [illegible]	– As adjuvant setting	– As adjuvant setting
Metastatic setting			
– As locally advanced setting plus liver, lung or soft tissue diagnostic biopsies, wound care and movement procedural pain	– As neo-adjuvant setting	– As adjuvant setting	– As adjuvant setting plus synergistic pain effects between iatrogenic and disease-related causes in long-term cancer survivors

RT, radiotherapy; TACE, transarterial chemoembolisation.

VERTEBRAL AUGMENTATION





The Metastatic Spine Disease Multidisciplinary Working Group Algorithms

Adam N. Wallace, Clifford G. Robinson, Jeffrey Meyer, Nam D. Tran, Afshin Gangi, Matthew R. Callstrom, Samuel T. Chao, Brian A. Van Tine, Jonathan M. Morris, Brian M. Bruel, Jeremiah Long, Robert D. Timmerman, Jacob M. Buchowski, Jack W. Jennings

The Oncologist 2015;20:1205–1215; first published on September 9, 2015; http://dx.doi.10.1634/theoncologist.2015-0085

VERTEBRAL AUGMENTATION

National Comprehensive Cancer Network® — NCCN Guidelines Version 1.2020 — Adult Cancer Pain

MANAGEMENT STRATEGIES FOR SPECIFIC CANCER PAIN SYNDROMES

Moderate to severe cancer pain is treated with opioids as indicated (PAIN-3 and PAIN-4); these interventions are meant to complement opioid management. Adjuvant analgesics are used depending on the pain diagnosis, comorbidities, and potential for drug interactions. Integrative interventions should also be optimized. (See PAIN-J)

- Pain from mucositis, pharyngitis, and esophagitis:
  - Gabapentin, pregabalin
  - Local anesthetic formulations/oral care protocols
  - For more information, see https://www.ons.org/pep/mucositis
- Bone pain without oncologic emergency:
  - NSAIDs, acetaminophen, or steroids[a] See Non-Opioid Analgesic (Nonsteroidal Anti-Inflammatory Drugs [NSAIDs] and Acetaminophen) Prescribing (PAIN-K)
  - Consider bone-modifying agents (eg, bisphosphonates, denosumab).
  - Diffuse bone pain: Consider hormonal therapy or chemotherapy, corticosteroids[a] and/or systemic administration of radioisotopes
  - Local bone pain:
    - Consider local RT, nerve block (eg, rib pain), vertebral augmentation, or percutaneous ablation techniques.
    - Assess for impending fracture with plain radiographs.
  - Consider physical medicine evaluation.
  - (PAIN-L)
  - Consider orthopedic consultation for stabilization, if feasible.
  - Consider referral to a pain specialist for interventional consultation. See Interventional Strategies (PAIN-M)
- Bowel obstruction
  - Evaluate etiology of bowel obstruction. If resulting from cancer, consider surgical intervention.
  - For medical management of partial bowel obstruction, consider corticosteroids[a] and/or metoclopramide.
  - Palliative management of bowel obstruction could include bowel rest, nasogastric suction (or percutaneous gastrostomy drainage), corticosteroids,[a] H2 blockers, anticholinergics (ie, scopolamine, hyoscyamine, glycopyrrolate), antiemetics (see PAIN-F 2 of 3), and or octreotide.
- Nerve pain
  - Nerve compression or inflammation:
    - Trial of corticosteroids[a]
  - Neuropathic pain:
    - Trial of antidepressant, see PAIN-G and/or
    - Trial of anticonvulsant, see PAIN-G
    - Consider trial of topical agent, see PAIN-G
    - For refractory pain, consider referral to a pain specialist and/or the use of interventional strategies. See Interventional Strategies (PAIN-M)
- Painful lesions that are likely to respond to antineoplastic therapies
  - Consider trial of radiation, hormones, or chemotherapy.
- For severe refractory pain in the imminently dying, consider palliative sedation (See NCCN Guidelines for Palliative Care).

National Comprehensive Cancer Network® — NCCN Guidelines Version 1.2018 — Metastatic Spine Tumors

PRESENTATION — TREATMENT — ADJUVANT TREATMENT

No tumor → Evaluate for other causes of pain and/or neurologic symptoms[i]

Spinal cord compression[f] → Steroids[g] → Surgery[k,l,m] followed by RT (category 1) or Primary RT[n] or In the absence of clinical myelopathy, primary chemotherapy[e] if chemosensitive tumor (eg, lymphoma, germ cell tumor, myeloma) →

No spinal cord compression[f]:
- Fracture or spinal instability[h] → Surgical stabilization or Vertebral augmentation[o] → Followed by RT[n] →
- No fracture or spinal instability → ... (preferred) or Chemotherapy[e] (if chemosensitive tumor) or Surgery[m] (selective cases) followed by RT → Consider surgery[m] or SRS[n] if: • Deterioration during RT • Intractable pain • Tumor progression →

See Follow-up (SPINE-3)

National Comprehensive Cancer Network. Adult Cancer Pain (Version 2.2014).

VERTEBRAL AUGMENTATION

- Radiotherapy
- Chemotherapy
- Ferrus Oxide
- Radioisotopes
- Thermal Cement

IOP Publishing — Physics in Medicine and Biology
Phys. Med. Biol. 55 (2010) 2451–2463

Evaluation of a radiation transport modeling method for radioactive bone cement

T S Kaneko[1], V Sehgal[2], H B Skinner[3], M S A L Al-Ghazi[2], N S Ramsinghani[2] and J H Keyak[4]

[1] Department of Radiological Sciences, B170 Med Sci I, University of California, Irvine, CA 92697, USA

Acrylic cement added with antiblastics in the treatment of bone metastases

ULTRASTRUCTURAL AND IN VITRO ANALYSIS

M. A. Rosa, G. Maccauro, A. Sgambato, R. Ardito, G. Falcone, V. De Santis, F. Muratori

From the Catholic University, Rome, Italy

Contents lists available at ScienceDirect
Acta Biomaterialia
journal homepage: www.elsevier.com/locate/actabiomat

PMMA-based bone cements containing magnetite particles for the hyperthermia of cancer

M. Kawashita *, K. Kawamura, Z. Li

Graduate School of Biomedical Engineering, Tohoku University, Sendai 980-8579, Japan

Pain Physician 2009; 12:887-891 • ISSN 1533-3159

Focused Review

Polymethylmethacrylate and Radioisotopes in Vertebral Augmentation: An Explanation of Underlying Principles

Ariel E. Hirsch, MD[1], Barry S. Rosenstein, PhD[2], David C. Medich, PhD, CHP[3], Christopher B. Martel, CHP[4], and Joshua A. Hirsch, MD[1]

IZI Medical Products — Exothermic cement for tumor that polymerises at 88° C

VERTEBRAL AUGMENTATION

Cytotoxic effect of drugs eluted from polymethylmethacrylate on stromal giant-cell tumour cells

AN *IN VITRO* STUDY

Acrylic cement added with antiblastics in the treatment of bone metastases

ULTRASTRUCTURAL AND IN VITRO ANALYSIS

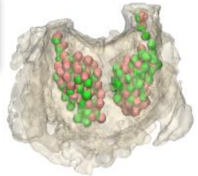
M. A. Rosa, G. Maccauro, A. Sgambato, R. Ardito, G. Falcone, V. De Santis, F. Muratori

From the Catholic University, Rome, Italy

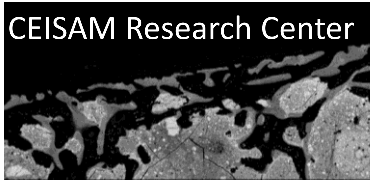
- Antimitotic Agents

- Titanium Microspheres

Vit Ortho



- Bisphosphonate Release from a CPC for Osteosarcoma



VERTEBRAL AUGMENTATION

Which Lesion will benefit from which procedure

- MDT

What is the objective ??

- Construct should be durable
- Allow Fast Mobilization
- Provide biomechanical Stability

RF ABLATION

Dimitrios K Filippiadis MD, PhD, MSc, EBIR
Associate Professor of Diagnostic and Interventional Radiology
2nd Radiology Dpt, University General Hospital "ATTIKON"
Medical School, National and Kapodistrian University of Athens

PMMA and new fractures

- **OUTLINE:**

- Products in the market
- Ind- CI
- Technique
- Literature data
- Ready for prime time?

BONE ABLATION

ISSUES TO CONSIDER PRIOR TO ABLATION:

- **CLINICAL**
- Local vs Diffuse bone pain
- “Mechanic” vs “Inflammatory” pain
- Performance status

- **TECHNICAL**
- Review recent cross sectional imaging (x rays, CT, MRI, PET/CT)
- Lesion shape / location / lytic vs blastic
- Impeding pathologic fracture (SINS)
- Vascularity
- Close by sensitive structures

A.N. Walace et al. The Oncologist 2015;20:1205–1215
Ratasvuori M et al. Surg Oncol 2013;22:132-138

BONE ABLATION

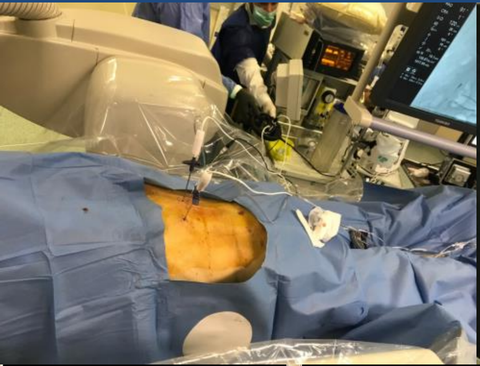
Why to use:

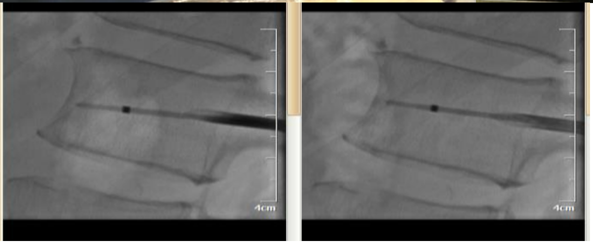
- Minimally invasive approach
- Well-tolerated even in patients with co-morbidities or with extensive disease
- Overall morbidity of the procedure is low - impressive and reliable pain relief
- May assist in liquefying the tumor and allowing for better fill of the cement

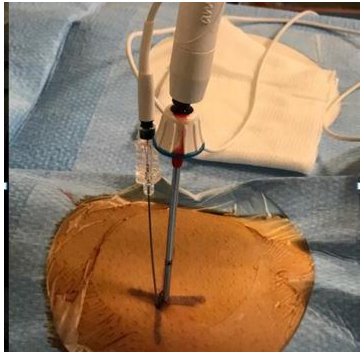
BONE ABLATION

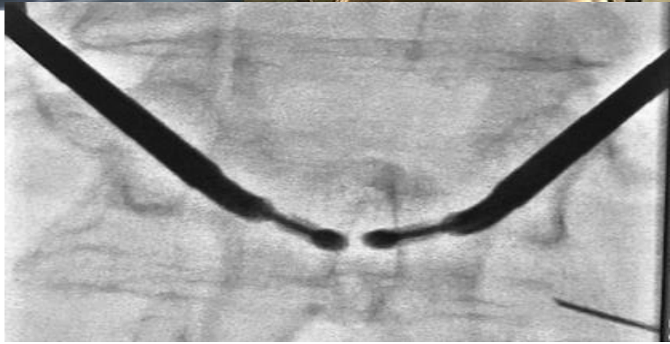
VIRTUES AND SINS	RFA	MWA	CA	HIFU
ABLATION ZONE SIZE - SHAPE	++	+++	++++	+
INTRA-PROCEDURAL PAIN	+	+++	++++	++++
EQUIPMENT – SET UP	+++	++++	++	+
LITERATURE DATA	++++	++	++++	++
COST	++++	++++	++	+
TIME CONSUMING	++	++++	+	+
HEAT SINK EFFECT	+	++++	++	+++

BONE ABLATION









Patients who benefit from RFA

- ✓ with **focalized pain from metastatic spinal tumor**
- ✓ with **radio-resistant tumors**
- ✓ with **persistent and/or recurrent pain** after radiation therapy
- ✓ with **posteriorly positioned** metastatic tumors
- ✓ who have reached their **maximum radiation dose limit**
- ✓ with **focalized pain** and symptoms preventing palliative radiation
- ✓ cannot undergo other palliative treatments due to **concurrent systemic treatments**
- ✓ in which **myelosuppression** is of concern

- Indications for Use
  - indicated for palliative treatment in spinal procedures by ablation of metastatic malignant lesions in a vertebral body

- Risks and Contraindications
  - Use of device is contraindicated in patients with heart pacemakers or other electronic device implants

OSTEOID OSTEOMA – spinal osteoid osteoma

- Lumbar spine > cervical spine > thoracic spine > sacrum
- Most commonly the nidus is located in the neural arch
- radicular pain, gait disturbance, limb atrophy, and painful scoliosis due to asymmetric muscle spasm
- when scoliosis is present, the nidus typically is on the concave side of the lumbar curvature

• Chai FW et al Radiologic Diagnosis of Osteoid Osteoma: From Simple to Challenging Findings. Radiographics 2010; 30:737–749

• Jackson et al. Osteoid osteoma and osteoblastoma: similar histologic lesions with different natural histories. Clin Orthop Relat Res 1977 (128):303–313

•Saifuddin et al. Osteoid osteoma and osteoblastoma of the spine: factors associated with the presence of scoliosis. Spine (Phila Pa 1976) 1998;23(1): 47–53

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ATTIKON

RFA OSTEOID OSTEOMA

Ablation of osteoid osteomas with a per

Rosenthal DI[1], J Bone Joint Surg Br. 2001 Apr;83(3):391-6.

Author in

Abstract
Osteoid oste
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PMID: 1549690
[Indexed for ME

Percutaneous radiofrequency

Lindner NJ[1], J Vasc Interv Radiol. 2001 Jun;12(6):7

Author i

Abstract
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complicatio

PMID: 113414
[Indexed for M

Osteoid osteoma: CT-

Woertler K[1], Vestring T, Boettner F

Author information

Abstract
PURPOSE: To evaluate compu
with regard to technical and clin
MATERIALS AND METHODS: I
pelvis, n = 2; humerus, n = 1; u
cases after one (n = 10) or two
general or spinal anesthesia. A
coaxial drill system or an 11-ga
rigid RF electrode with a diame
placed within the center of the
permanent relief of pain and re
ablation, treatment was regarde
RESULTS: All procedures were
recurrence of pain 3, 5, and 7 m
successfully in a second proce
CONCLUSION: CT-guided perc
osteoid osteoma.

Radiology. 2003 Oct;229(1):171-5. Epub 2003 Aug 27.

Osteoid osteoma: percutaneous treatment with radiofrequency energy.

Rosenthal DI[1], Hornicek FJ, Torriani M, Gebhardt MC, Mankin HJ.

Author information

Abstract

PURPOSE: To report our experience with technical success, complications, and long-term clinical success of radiofrequency (RF) ablation of osteoid osteoma.

MATERIALS AND METHODS: After needle biopsy, computed tomography (CT)-guided percutaneous RF ablation was performed with general or spinal anesthesia. With an RF electrode, the lesion was heated to 90 degrees C for 6 minutes. Patient age and sex, lesion size and location, biopsy results, and complications were recorded. Clinical success was assessed at a minimum of 2 years after the procedure. Significance of patient age and sex and lesion location and size as a predictor of biopsy result was tested by means of chi2 analysis. In addition, effects of patient age and sex, lesion location and size, and biopsy results on clinical success were tested with the Fisher exact test.

RESULTS: During an 11-year period, 263 patients who were suspected of having osteoid osteoma underwent 271 ablation procedures. All procedures were technically successful. There were two anesthesia-related complications (aspiration, cardiac arrest) and two minor procedure-related complications (cellulitis, sympathetic dystrophy). Results at biopsy were positive in 73% (197 of 271 biopsies). Two-year follow-up data were available for 126 procedures. The other procedures had been performed more recently or the patients could not be contacted. There was complete relief of symptoms after 112 of the 126 procedures (89%). For procedures performed as the initial treatment, the success rate was 91% (107 of 117 procedures). Procedures for recurrent lesions had a significantly lower success rate (six of 10 procedures [60%], P <.001). Clinical outcome was not dependent on biopsy result, patient age or sex, or lesion size or location.

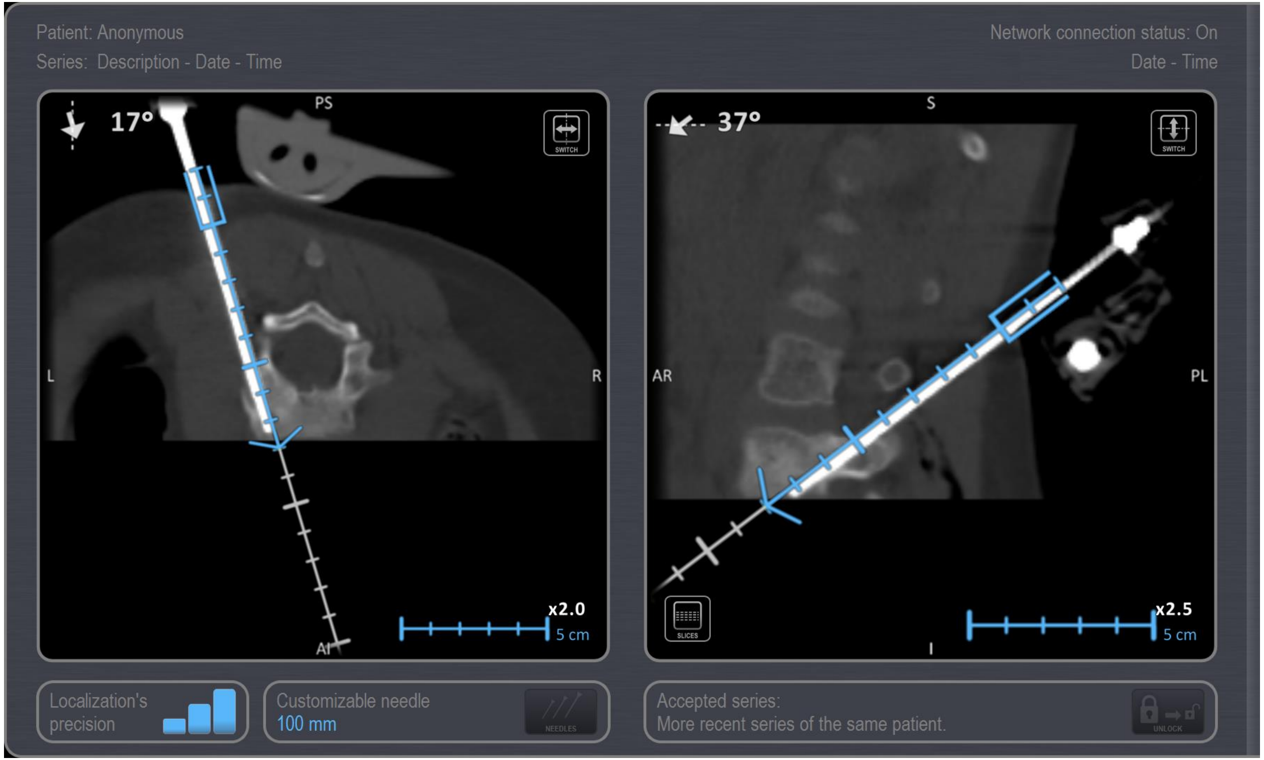
CONCLUSION: CT-guided percutaneous RF ablation of osteoid osteoma is a safe and effective technique.

Comment in
Radiofrequency thermoablation in the treatment of osteoid osteoma. [Radiology. 2004]

PMID: 12944597 DOI: 10.1148/radiol.2291021053

[Indexed for MEDLINE]

STRATEGIC – quality assurance



OSTEOBLASTOMA

- On routine histologic analysis is essentially indistinguishable from OO - tumor size of 2 cm or larger is the main histopathologic criterion to distinguish this lesion from OO

- Patients are usually younger than 30 years of age and the lesion is more common in males (by x2:1)

Motamedi K, Seeger LL. Benign bone tumors. Radiol Clin N Am 49 (2011) 1115–1134

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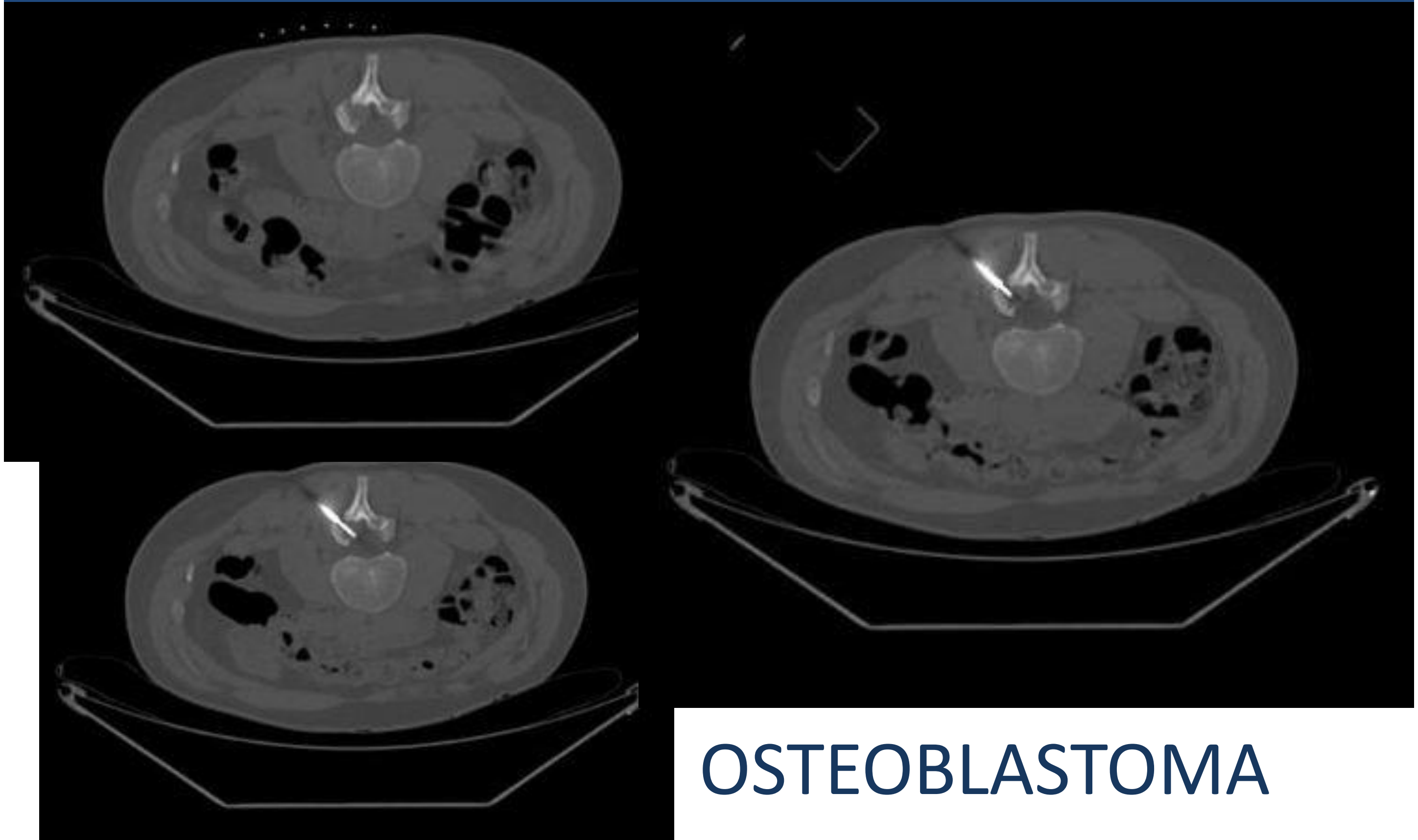
L2-L3 FACET JOINT LESION



OSTEOBLASTOMA

L2-L3 FACET JOINT LESION

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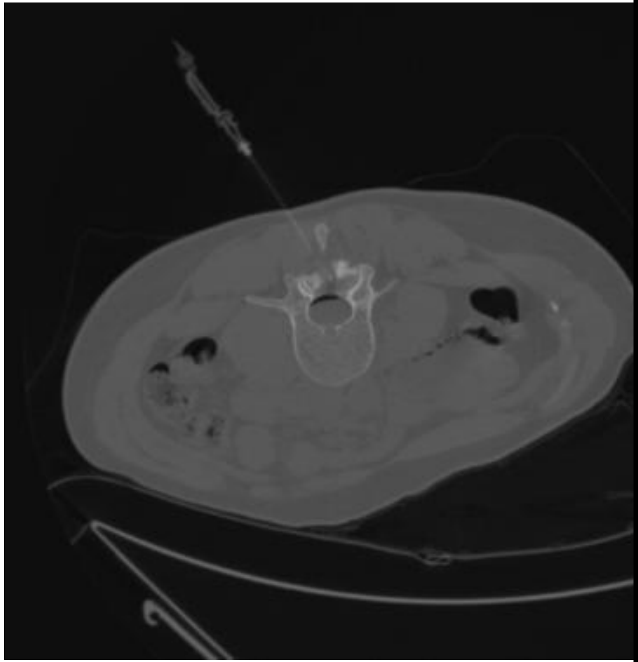

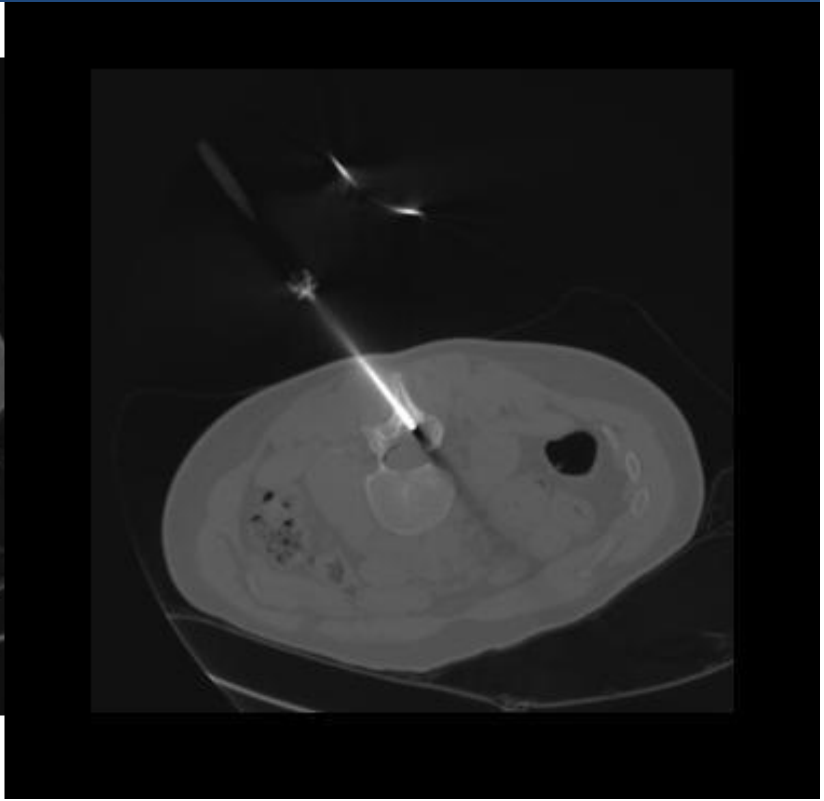

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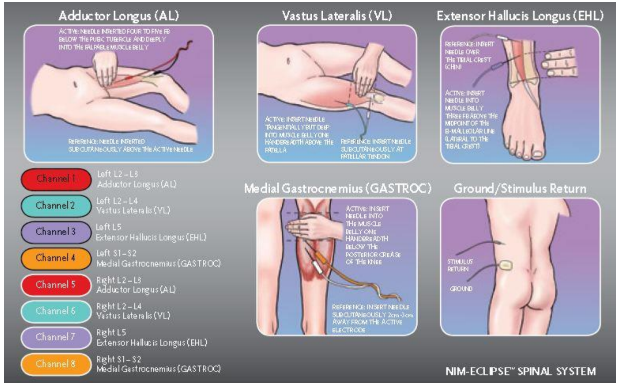

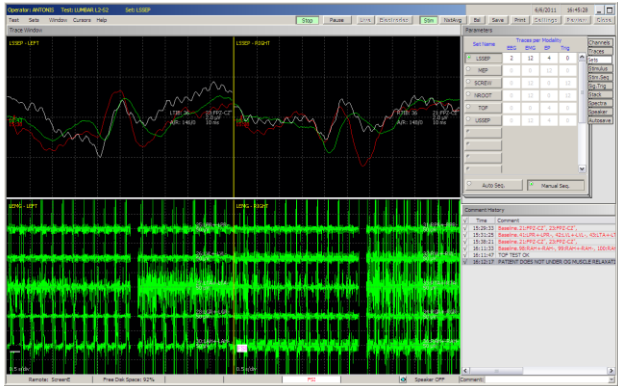

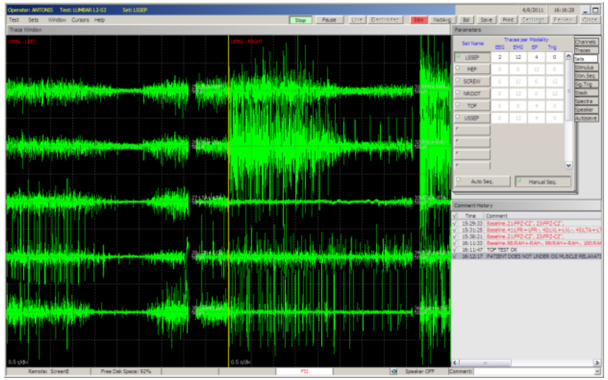

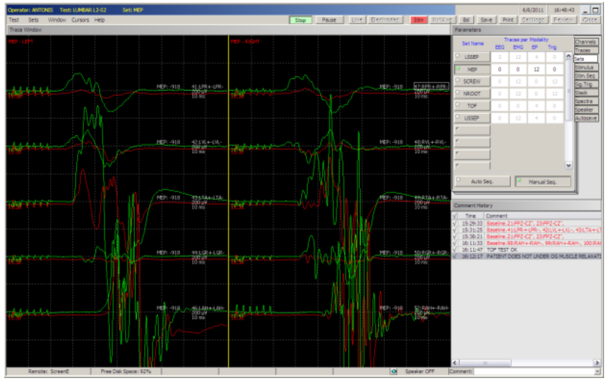

L2-L3 FACET JOINT LESION

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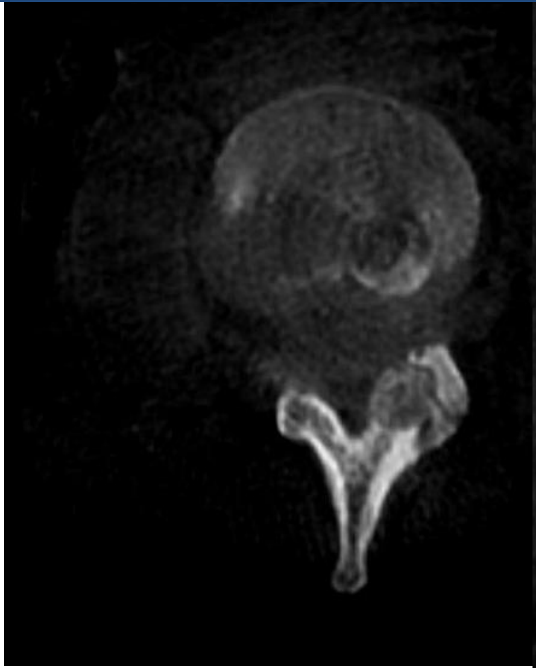


INTERVENTIONAL STRATEGIES

Interventional consultation[1]
- Major indications for referral:
  - Pain likely to be relieved with nerve block (eg, pancreas/upper abdomen with celiac plexus block, lower abdomen with superior hypogastric plexus block, intercostal nerve)
  - Failure to achieve adequate analgesia and/or the presence of intolerable adverse effects (may be handled with intraspinal agents, blocks, spinal cord stimulation, or destructive neurosurgical procedures)

Current Oncology Reports (2019) 21:105
https://doi.org/10.1007/s11912-019-0844-9

PALLIATIVE MEDICINE (A JATOI, SECTION EDITOR)

Check for updates

The Role of Ablation in Cancer Pain Relief

Dimitrios K. Filippiadis[1] • Steven Yevich[2] • Frederic Deschamps[3] • Jack W. Jennings[4] • Sean Tutton[5] • Alexis Kelekis[1]

(ie, peripheral neuropathy, neuralgias, complex regional pain syndrome)
- Percutaneous ablation techniques for bone lesions
  - ◇ Specific therapies for bone pain are outside the scope of this guideline. Other resources (eg, Filippiadis 2019) may be referred to for more information

[1] Patient prognosis should be communicated to interventional pain colleagues as an important consideration when selecting interventional pain therapies.
[2] Infection, coagulopathy, very short life expectancy, distorted anatomy, patient unwillingness, medications that increase risk for bleeding (eg, anti-angiogenesis agents such as bevacizumab), or technical expertise is not available.

Note: All recommendations are category 2A unless otherwise indicated.
Clinical Trials: NCCN believes that the best management of any patient with cancer is in a clinical trial. Participation in clinical trials is especially encouraged.

Benefits of Simultaneous RF Ablation?

Benefits of Simultaneous Bilateral Ablation

- Efficiently generate large areas of ablation with limited overlapping zones
- Spatial relationship between conductive heating and convective cooling
  - Generates 2 areas of resistive & conductive heating in relative close proximity
  - Reduces effect of convective cooling (heat sink)
- Reducing temperature delta between areas of resistive heating and adjacent tissue, decreasing distance heat must be conducted
- Reduces power required to conduct heat through tissue, lowering incidence of increased impedance

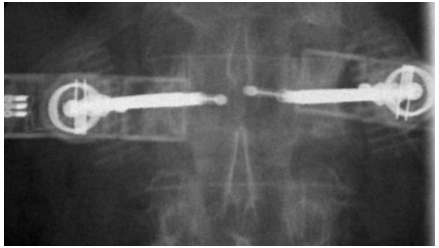
Challenges in Simultaneous RF Ablation?

- Location of electrodes
  - Optimal location in VB and proximity of dual electrodes
  - VB anatomy (large size, oblique pedicle orientation)
  - Tumor location (posterior, diffuse)

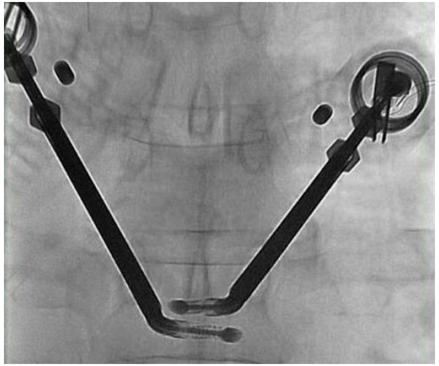
- Limitations of straight electrodes
  - Limit access to posterior third
  - Difficult to reorient, achieve optimal proximity of electrodes required to achieve coalescence

Procedural considerations in SBA with STAR

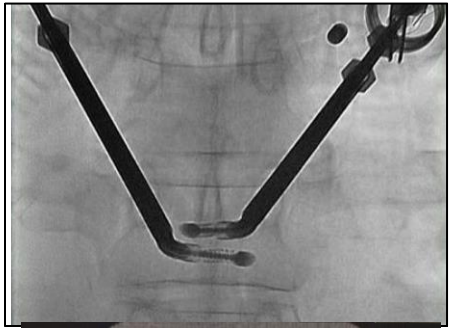
- Proximity of Electrodes:
  - Should not touch after electrode fully extended
  - AP view landmark
    - spinous process. Electrodes on either side of the spinous process

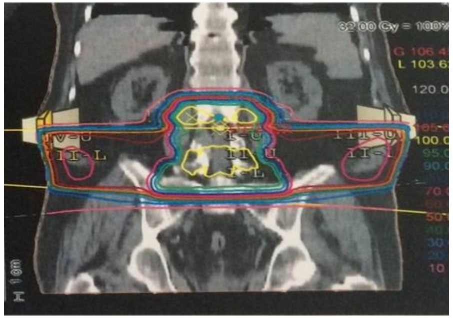


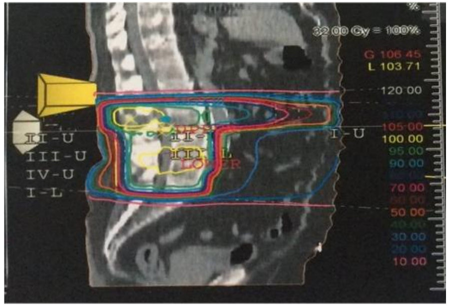
    - If overlapping distance equivalent to width of SpineSTAR



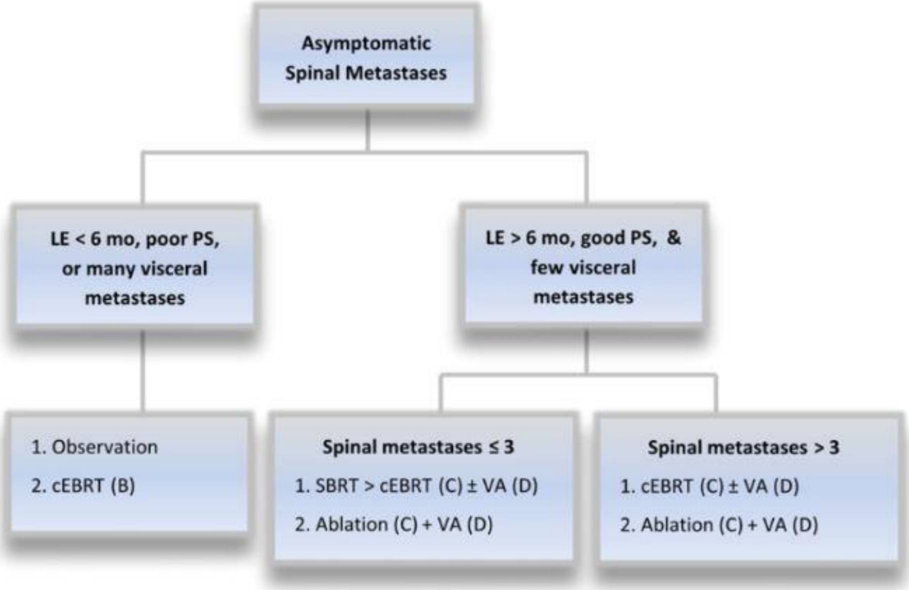
CAN WE CHALLENGE RTH?

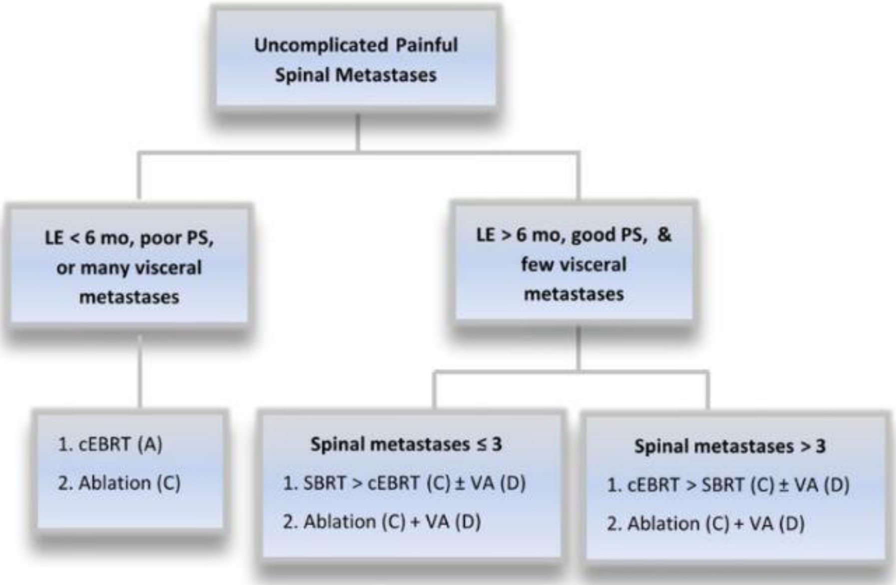






Neurogenic & Bone Cancer Pain





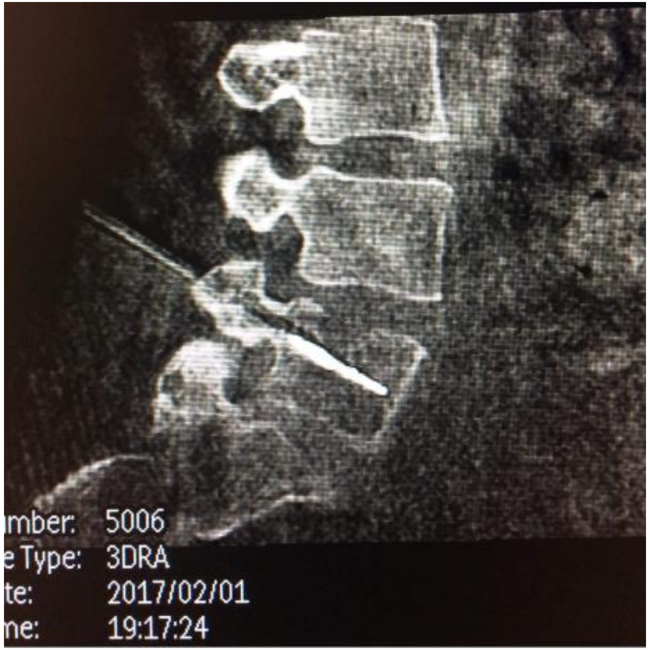
The Metastatic Spine Disease Multidisciplinary Working Group Algorithms

Adam N. Wallace, Clifford G. Robinson, Jeffrey Meyer, Nam D. Tran, Afshin Gangi, Matthew R. Callstrom, Samuel T. Chao, Brian A. Van Tine, Jonathan M. Morris, Brian M. Bruel, Jeremiah Long, Robert D. Timmerman, Jacob M. Buchowski, Jack W. Jennings

The Oncologist 2015;20:1205–1215; first published on September 9, 2015; http://dx.doi.10.1634/theoncologist.2015-0085

CASE

Unipedicular Approach



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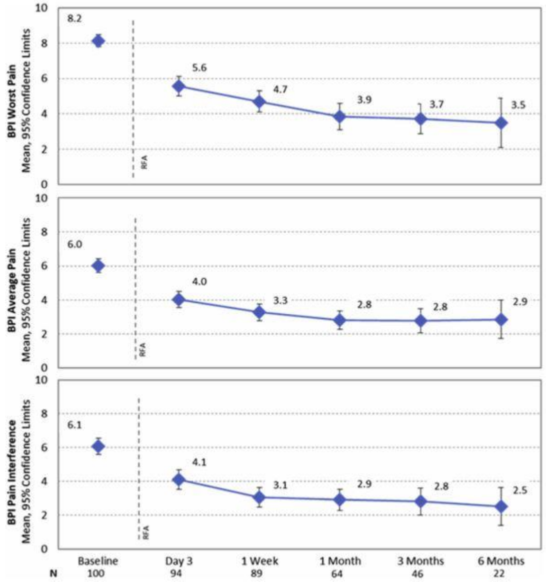
BONE ABLATION

Radiofrequency Ablation for the Palliative Treatment of Bone Metastases: Outcomes from the Multicenter OsteoCool Tumor Ablation Post-Market Study (OPuS One Study) in 100 Patients

100 patients (87-13 spine-sacrum/illium), 14 centers
97% of ablations were followed by cementoplasty
Variable neoplasmatic substrate
Mean worst pain score decreased from
8.2±1.7 at baseline to 3.5 ± 3.2 at 6 mo

Conclusions: Results from this study show rapid (within 3 d) and statistically significant pain improvement with sustained long-term relief through 6 mo in patients treated with RF ablation for metastatic bone disease.



Levy et al J Vasc Interv Radiol . 2020 Nov;31(11):1745-1752.

OPuS One safety summary

0

delayed skeletal-related fractures or neurologic injuries reported.

0 delayed skeletal-related fractures or neurologic injuries reported.

6 device, therapy, and/or procedure-related adverse events in 6 patients (2.9%; 6/206) reported

- 3 considered serious: intra-abdominal fluid collection, pneumonia, respiratory failure.

82 deaths (40%; 82/206) deaths reported during the course of the study.

- All deaths were classified by the Clinical Events Committee and Investigator.
- None were related to the device, therapy, or procedure.

conclusion

- Levy J, David E, Hopkins T, et al. Improvement in quality of life in patients treated for painful osseous metastases with radiofrequency ablation: The OPuS One Study. Abstract presented at the Society for Interventional Radiology Annual Scientific Meeting. Virtual. 2021.

1

In a large, multicenter prospective global prospective trial, RFA demonstrated to be a clinically impactful palliative treatment option for patients with metastatic bone lesions.

2

RFA provided swift (3 days post RFA), significant, and sustained (12 months post RFA) improvements in pain relief and quality of life.

3

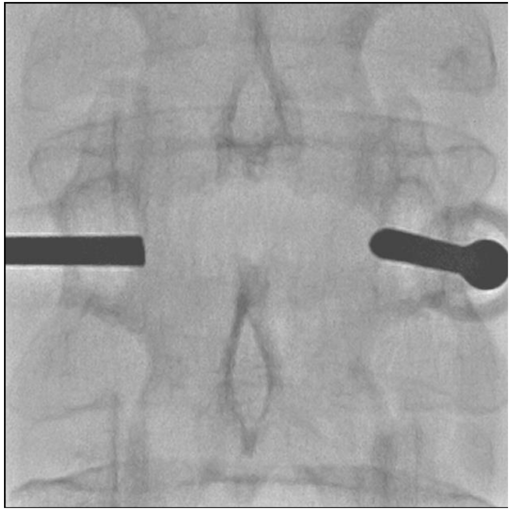
RFA is safe with no delayed skeletal-related events fractures reported during study.

Case

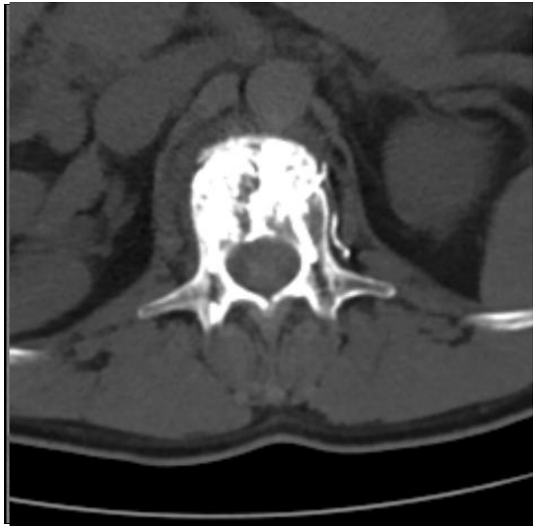
- 41yo Male Patient
- Sacral lesion biopsied: Hemangiopericytoma
- Treated by RF

New Lytic L1 Lesion

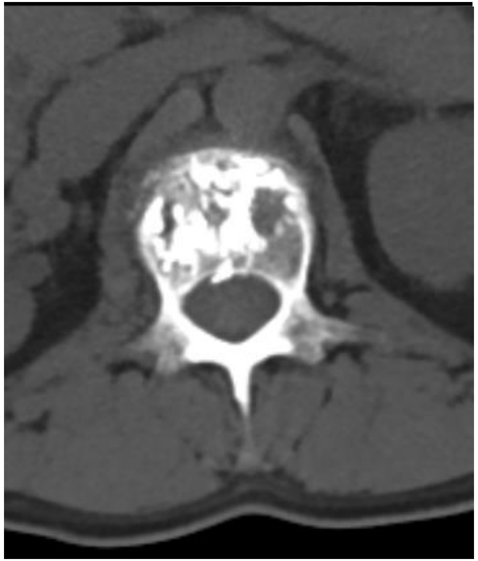

Osteocool and Augmentation



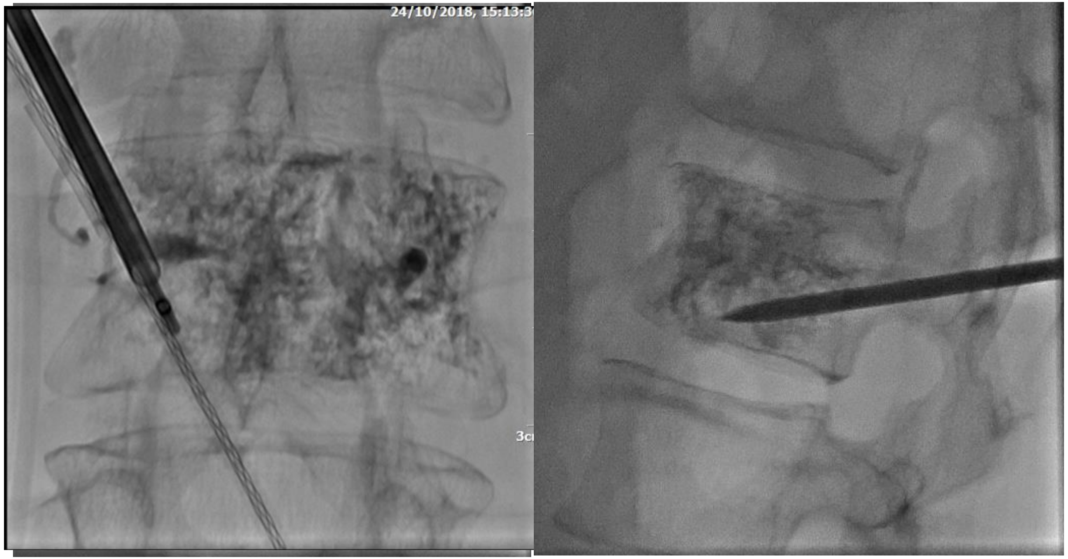
Bilateral Augmentation



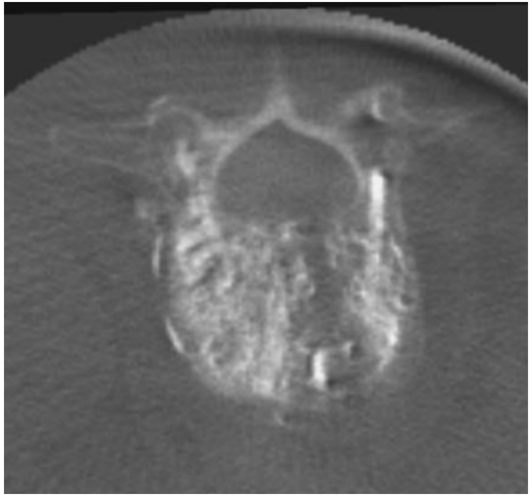
10 months later

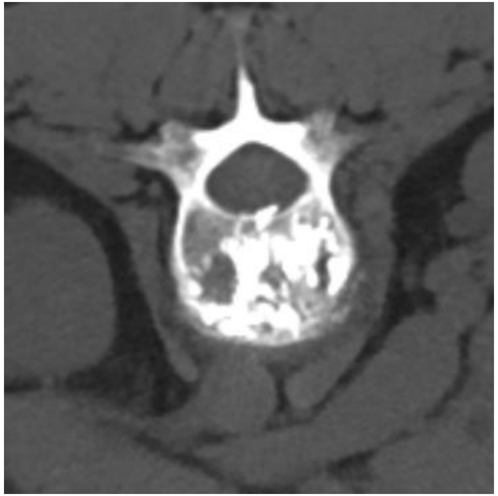


Re-Treatment of LtP Ablation



RE-TREATMENT OF LTP AUGMENTATION





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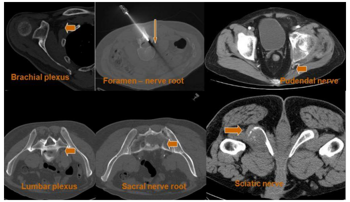
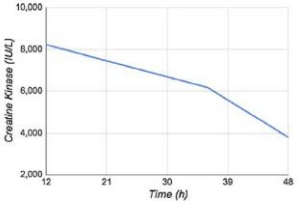
BONE ABLATION

Avoiding Complications:

- Neural injury
- Applicator placement - damage
- Fracture risk
- Inadvertent osteochondral injury
- Large tumor treatment and tumor lysis





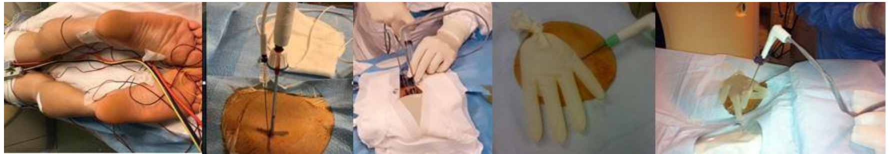
Kurup et al Cardiovasc Intervent Radiol 2017;40(2):166-176

- **Passive thermal protection**
  - Thermocouples
  - Intra-operative neurological monitoring systems

  (neurodiagnostic EEG, EMG and evoked potential electrodes

  and accessories, electrostimulation of peripheral nerves)
- **Active thermal protection - insulation**
  - $CO_{2,}$ - air
  - Hydrodissection
  - Skin warming/cooling

Tsoumakidou et al CVIR 2013
Filippiadis et al Insights Imaging 201
Kurup et al CVIR 2017



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IR-RTH COLLABORATION

- **COMMON AIM:** to cure/control tumor or to relieve symptoms with as little collateral damage to normal tissue as possible

- **COMMON ORIGIN:** for more than half a century, both fields were intimately linked in terms of training and clinical practice

Andreas Adam and Lizbeth M. Kenny. Interventional oncology in multidisciplinary cancer treatment in the 21st century. Nat Rev Clin Oncol. 2015 Feb;12(2):105-13.

IR-RTH STRATEGIC COLLABORATION

- **DEFINE EVIDENCE-BASED CRITERIA:** for choosing or combining these two modalities (size, nature and location of tumor + vulnerable adjacent structures + status of the affected organ - patient’s choice)

- **COMMITMENT TO WORK TOGETHER IN PROMINENT CENTERS:** “the Athenian experience” – facility / staff for outpatient clinics / ward support for inpatients

RFA + conventional EBRT

Feasibility study of RFA adjunctive effect in combination with RT

	RT only n=30	RFA+RT n=15	P-value
Overall response	60%	93%	< .05
Complete pain relief	17%	53%	< .05
Time to Pain Relief	9 wks	3 wks	< .01
Recurrent pain Retreatment need	26.6%	6.7%	NS

- Safe and may be more effective than EBRT alone
- Improved degree, rate, duration of pain relief in painful spinal metastases

Di Staso M et al. European radiology. 2011;21(9):2004-10

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CLINICAL – Complimentary

Combined Ablation and Radiation Therapy of Spinal Metastases: A Novel Multimodality Treatment Approach

21 patients, 36 spinal mets
Concurrent treatment: <4 wk between RT+ Ablation
Variable neoplasmatic substrate
Mean worst pain score decreased from 8.0±2.3 at baseline to 2.9 ± 3.3 at 1 mo

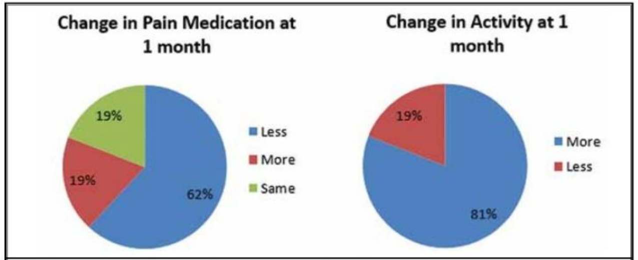

Fig. 2. Activity and pain medication use changes after concurrent RT and ablation.

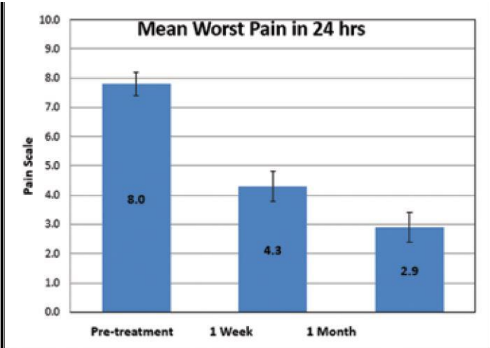

Fig. 1. Pain scale response following concurrent RT and ablation treatment.

Conclusions: Percutaneous ablation and concurrent RT is safe and effective in palliating painful spinal metastases and can be effective in those who have radiation resistant tumor histology

Greenwood et al J Pain Physician 2015; 18:573-581

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CLINICAL – Complimentary

Interaction of radiation therapy and radiofrequency kyphoplasty in the treatment of myeloma patients

86 myeloma patients with VCF were treated with RF+KP followed by radiation therapy (RFK group) or vice versa (RT group)
Both groups achieved comparable outcomes in height restoration, pain reduction and impact of functional Impairment but:
More cement leakages and additional fractures were noted in the RT group

Conclusions: With regard to higher rates of bone cement extrusion and additional fractures we recommend to perform radiation therapy before radiofrequency kyphoplasty though

Bornemann et al Technol Health Care . 2017;25(3):567-575

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CLINICAL – Complimentary

Radiofrequency thermoablation (RFA) and radiotherapy (RT) combined treatment for bone metastases: a systematic review

3 studies, 92 patients

Conclusions: The RFA-RT combined strategy appears to be promising in terms of efficiency and safety with adequate pain control and quality of life improvement

Piras et al Eur Rev Med Pharmacol Sci. 2021;25(10):3647-3654

Author (year)	Study design	n/N	Treatment	RT details	Main findings among patients with RFA-RT treatment.
Di Staso et al[31]	Observational, retrospective, historical controlled	45/45	RFA-RT (15) vs. RT alone (30).	The nominal prescribed dose was 20 Gy delivered in 5 fractions of 4 Gy	RFA-RT is safe and more effective than RT alone Complete pain response 16.6% (5/30) with RT and 53.3% (8/15) with RFA-RT (p=0.027) 12 weeks-overall response rate 59.9% (18 patients) for RT and 93.3% (14 patients) for RFA-RT (p=0.048).
Greenwood et al[32]	Observational, retrospective, historical controlled	21/21	RFA-RT (21 patients)	The majority of patients received 30 Gy in 10 fractions (12/22). Other treatment regimens included SBRT (6/22), 20 Gy in 5 fractions (1/22), and 8 Gy in a single fraction (1/22). Two treatment regimens were unknown	Decreased mean worst pain scores from 8.0 pre-procedure to 4.3 (p<0.02) at 1 week and 2.9 (p<0.0003) at 4 weeks post-treatment. Local tumor control rates 92% (12/13) and 100% (10/10) at 3- and 6-month follow-up (despite systemic metastatic progression)
Prezzano et al[33]	Observational, retrospective, controlled	26/26	RFA-RT (11) vs. RFA alone (15).	Eleven lesions treated with 3D-CRT received a median dose of 30 Gy in 3 Gy daily fractions and 1 patient received a single fraction of 8 Gy. Two patients underwent SBRT at 28 days post-RFA, both receiving 35 Gy in 5 fractions	No significant difference in pain scores between groups (p=0.96). Combined RFA-RT treatment showed a significant benefit both in time to LF (p=.002) and in OS (p=0.0045)

RF followed Rt after 6d

RT within 4 wk of RF

RT followed RF after 28 d

PATIENT FOLLOW UP

1 mo:

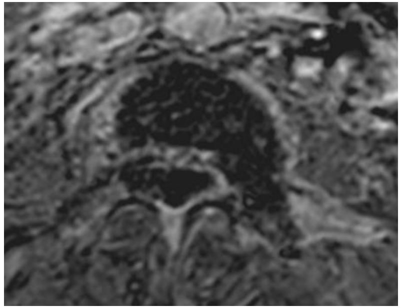
- Baseline MRI after treatment to allow post-ablation inflammation to subside (FAT-SAT+GD)

6-8 weeks:

- PET-CT scanning (requested by the oncologists) to evaluate systemic response, at which time evaluation of the ablated lesion can be performed

Subsequent imaging:

- At the discretion of the treating medical or surgical oncologist to assess for local tumor control
- When the patient complains of new or increasing pain at the site of ablation



TAKE HOME MESSAGE

- Osteoid osteoma: ablation is the GOLD STANDARD therapy
- RFA: cumulative data on terms of results – evidence for long term efficacy
- Osteoblastoma: more aggressive ablation session (esp in long bones)
- Know the anatomy and take care of sensitive structures - Bone is injured during all forms of ablation

TAKE HOME…….

- **BONE ABLATION CONCERNS**
- Access to the lesion
- Extent of ablation zone
- Protection of surrounding sensitive structures (nerves, joints, skin etc)
- Large sized tumors (technically challenging - myoglobinuria)
- Combo treatments (osseous augmentation, TAE)

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TAKE HOME.......

- **BONE ABLATION**
- Feasible, safe and efficacious technique aiming for pain palliation ± functional restoration
- Included in the NCCN Guidelines for Adult Cancer Pain

- Multiple ablation techniques available
- Optimize selection: patient (lesion) tailored approach to maximize efficacy

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ROLE OF IO IN OLIGOMETASTATIC BONE DISEASE

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Assistant Professor of Diagnostic and Interventional Radiology
2nd Radiology Dpt, University General Hospital "ATTIKON"
Medical School, National and Kapodistrian University of Athens

CANCER STATISTICS

- More than 1.4 million patients are diagnosed with cancer annually in the United States
- 70% will develop bone metastases

- **Scandinavian Skeletal Metastasis Registry:**
  - the incidence of cancer has increased by 18% during the last decade
  - cancer mortality rates have remained nearly constant (+2%)

A.N. Walace et al. The Oncologist 2015;20:1205–1215
Ratasvuori M et al. Surg Oncol 2013;22:132-138

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CANCER STATISTICS

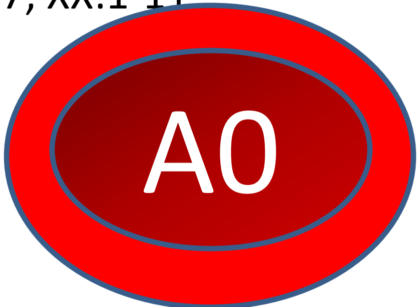
- **Skeletal system:** third most important filter for cancer metastases after lungs and liver
- **Spine:** the most common site of osseous metastatic disease
- **WHY SPINE?**
  - Presence of vascular red marrow in adult vertebrae
  - Communication of deep thoracic and pelvic veins with valveless vertebral venous plexuses

A.N. Walace et al. The Oncologist 2015;20:1205–1215
Ratasvuori M et al. Surg Oncol 2013;22:132-138

DEFINING TERMS

- **Oligometastatic disease**
  - <3-5 lesions, <3-5cm diameter
    - » Gangi et al. Quality Improvement Guidelines for Bone Tumour Management. CVIR 2010 33:706–713
- the presence of 1 and 5 distant metastases in <2 organs, although the exact number of metastases that should be considered remains debatable
  - ➢ deSouza et al. Strategies and technical challenges for imaging oligometastatic disease. EJCANCER 2017; XX:1-11

- **Ablation with curative intent**
  - Ablation volume – Safety margin (A0)



tumor
Ablation zone

MANAGEMENT OF BONE METASTASES

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MULTIDISCIPLINARY INPUT:

- Medical oncologists
- Radiation oncologists
- Surgeons (Ortho and/or Neuro)
- Interventional Radiologists

- CTH / bone-modifying agents
- RTH / SBRT
- Surgical techniques
- Minimally invasive interventions (percutaneous/trans-arterial)

MANAGEMENT OF BONE METASTASES

- **SURGERY:**
  - Technically challenging and morbid, prolonged recovery, delay systemic therapies
  - Metastasectomy is associated with higher complication rates

- **RTH:**
  - Applied in areas that have not reached limit
  - Limited by cumulative radiation tolerance of nearby organs
  - Based on tumor histology (eg sarcoma, melanoma GIST, RCC, NSCLC)
  - Does not improve stability (weakens adjacent bone with effect on pathologic fracture)

Kurup et al. AJR 2017; 209:713–721
Meyer et al Eur Urol 2017; 1-4

MANAGEMENT OF BONE METASTASES

	Rose et al[35] MSKCC (2009)	Boehling et al[36] MDACC (2012)	Cunha et al[34] UofT (2012)
Number of patients	71 spinal segments in 62 patients	123 spinal segments in 93 patients	167 spinal segments in 90 patients
Median follow-up (months)	13	14·9	7·4
SBRT median or total dose/ fraction	Median 24 Gy (range 18–24)/1	Total 18 Gy/1 (34%), 27 Gy/3 (49%), 30 Gy/5 (17%)	Total 20–24 Gy/1 (19%), 8–18 Gy/1 (3%), 18–24 Gy/2 (25%), 20–27 Gy/3 (35%), 30 Gy/4 (3%), 25–35 Gy/5 (15%)
Tumour characteristics	65% osteolytic, 18% osteosclerotic, 17% mixed	58% osteolytic, 21% osteosclerotic, 21% mixed	48% osteolytic, 26% osteosclerotic, 26% mixed
Tumour location	9% cervical, 66% thoracic, 25% lumbar-sacral	4% cervical, 54% thoracic, 42% lumbar-sacral	18% cervical, 46% thoracic, 36% lumbar-sacral
Incidence of VCF (%)	39%	20%	11%
Time to VCF (months)	Median 25	Median 3	Median 2, mean 3·3, 1-year FFP 87·3%
Salvage interventions (%)	3/27 (11%); 2 surgery, 1 cement augmentation procedure	10/25 (40%); 10 cement augmentation procedures	9/19 (47%); 3 surgery, 6 cement augmentation procedures
Significant predictors of VCF on multivariate proportional hazard analysis	Osteolytic tumour (HR 3·8, 95% CI 1·2–11·4); 41–60% vertebral body involvement (HR 3·9, 95% CI 1·1–14·2)	Age >55 years (HR 5·67, 95% CI 2·13–19·69); pre-SBRT VCF (HR 4·12, 95% CI 1·82–9·21); osteolytic tumour (HR 2·76, 95% CI 1·2–7·1)	Kyphosis/scoliosis (HR 11·1, 95% CI 3·0–41·7); osteolytic tumour (HR 12·2, 95% CI 2·6–58·8); lung histology (HR 4·3, 95% CI 1·2–16); liver histology (HR 34, 95% CI 0·024–192·5); ≥20 Gy dose per fraction (HR 6·82, 95% CI 1·83–25·42)

MSKCC=Memorial Sloan-Kettering Cancer Center. MDACC=MD Anderson Cancer Center. UofT=University of Toronto. SBRT=stereotactic body radiotherapy. VCF=vertebral compression fracture. FFP=fracture-free progression. HR=hazard ratio.

***Table:* Summary of studies reporting on VCF after spine stereotactic body radiotherapy**

65% of fractures occurred in the first 4 months

MANAGEMENT OF BONE METASTASES

- **ABLATION:**
  - Effective tumor destruction irrespective of histology
  - Minimally invasive
  - Combi[illegible] fixation techniques

N. Kurup et al. AJR 2017; 209:713–721

Electromagnetic - Thermal	• **Radiofrequencies (RFA)** • **Microwaves (MWA)** • **Laser (LITT)**
Thermal	• **Cryoablation (CWA)**
Electromagnetic - Biological	• **Irreversible Electroporation (IRE)**
Mechanical - Thermal	• **High Intensity Focused Ultrasound (HIFU)**

AUGMENTATION TECHNIQUES

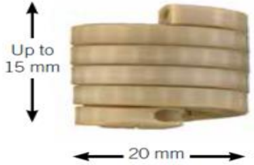
Ceme
nt
and
Needl

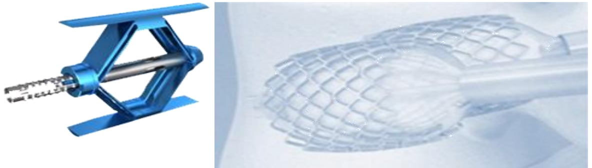
Vertebropla
sty Kits

Balloon
Kyphoplast
y

Curved
Needles,
Biologics

Implant-
Based
Technologies
and screw



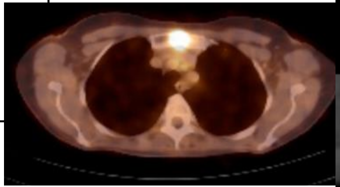


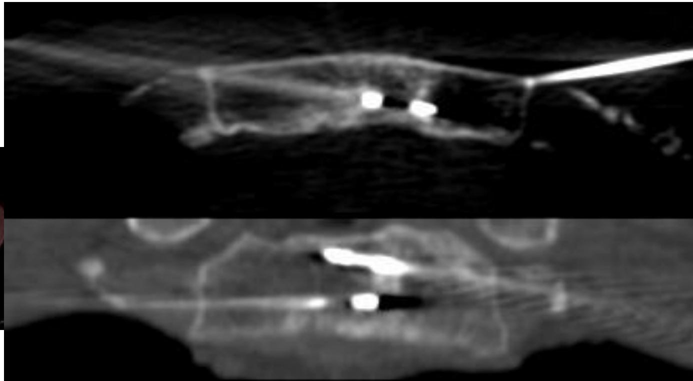
AUGMENTATION TECHNIQUES

- Visible ablation zone
- Large-sized ablation zone – ability to geometrically design the ablation zone (simultaneous use of up to 8 cryoprobes)
- Blastic lesions: ability of ice to penetrate bone
- Conscious sedation

- Time consuming (mean duration 3h and 5 min)
- High cost

Callstrom MA, Kurup N. Percutaneous ablation for bone and soft tissue metastases—why cryoablation? Skeletal Radiol (2009) 38:835–839





ABLATION TECHNIQUES

VIRTUES AND SINS	RFA	MWA	CA	IRE
ABLATION ZONE SIZE - SHAPE	++	+++	++++	++
INTRA-PROCEDURAL PAIN	+	+++	++++	++++
EQUIPMENT – SET UP	+++	++++	++	+
LITERATURE DATA	++++	+++	+++	+
COST	++++	++++	++	+
TIME CONSUMING	++	++++	+	+
HEAT SINK EFFECT	+	++++	++	++++

MANAGEMENT OF BONE METASTASES

Randomized Trials Ablation vs. Surgery / RTH
Randomized Trials RFA vs. MWA vs CWA

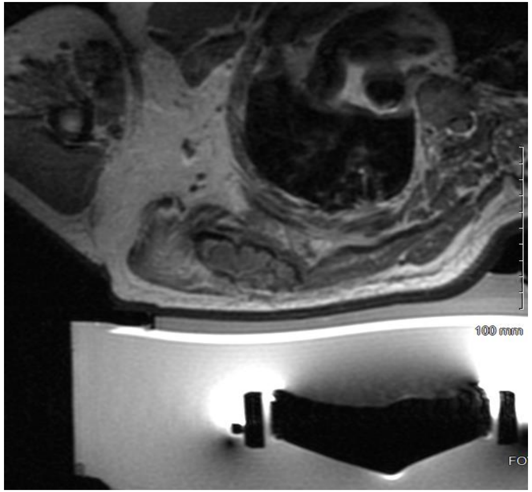
0

ABLATION TECHNIQUES

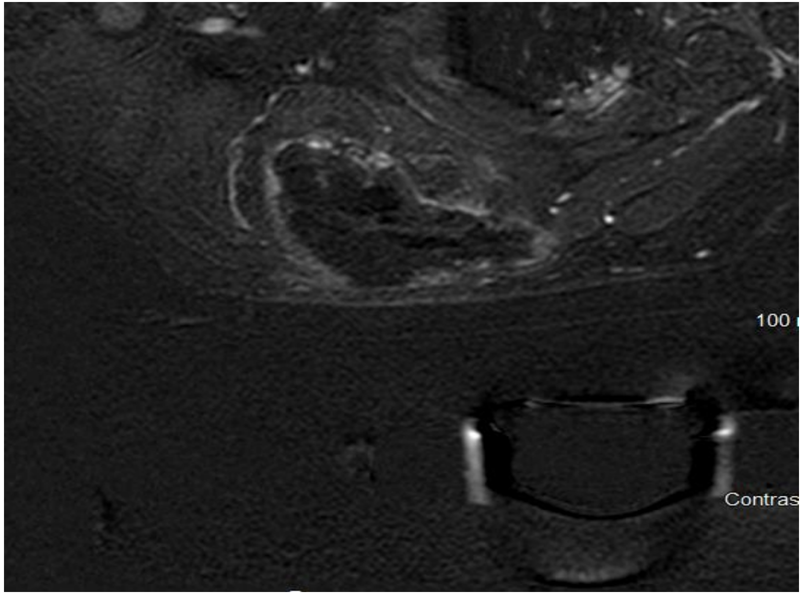
- RFA in 2010

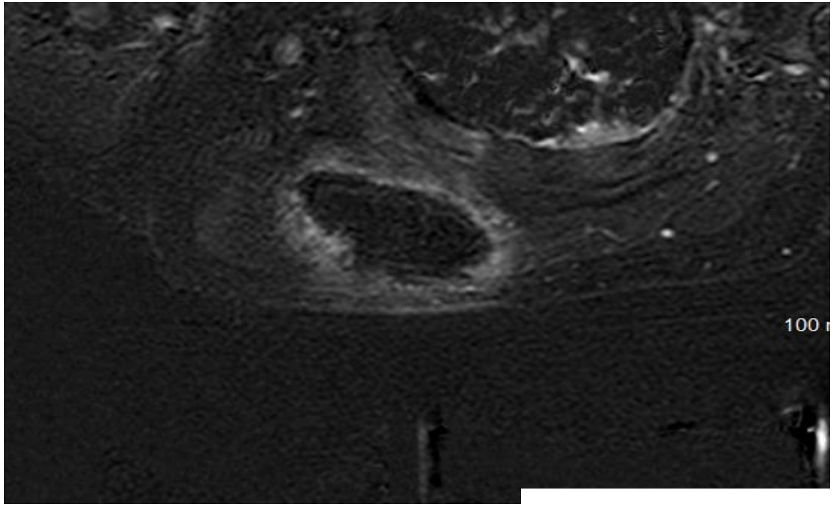
- Recurrent disease in 2016

- MRgFUS Planning



ABLATION TECHNIQUES





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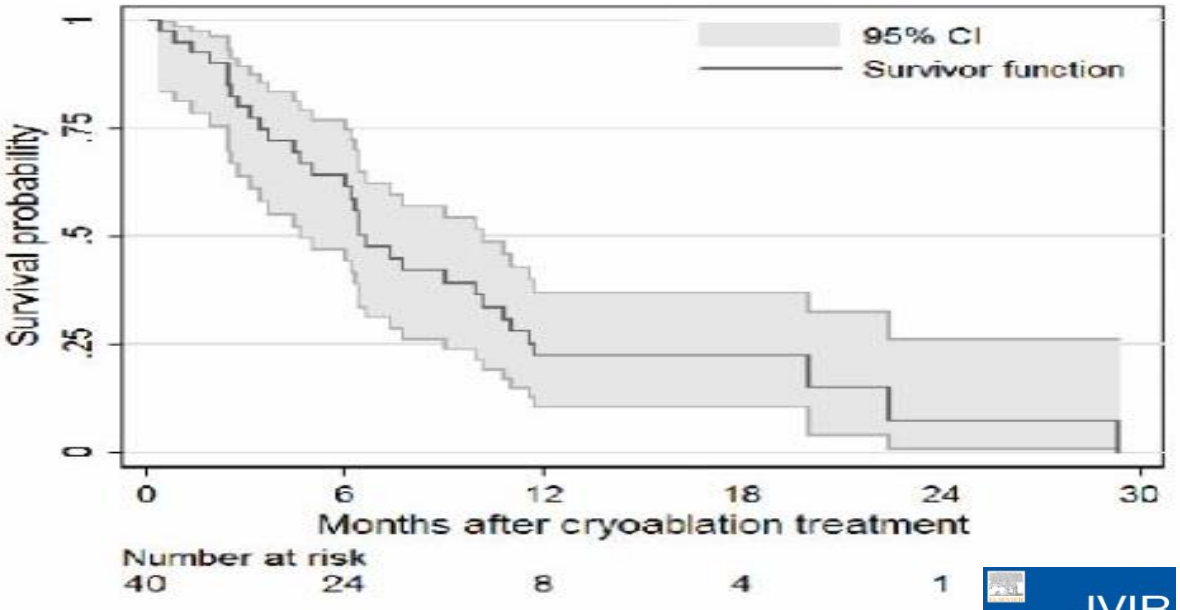
ABLATION TECHNIQUES

Author	Year	Tumor histology	Sites	Ablation modality	Average size (cm)	No. of patients (no. of tumors)	Local control No. (%) or %/y	Survival (%/y)	Follow-up (mo)	Major comp (no., %)[a]
Vaswani[62]	2018	Sarcoma	MSK	RFA, CA	3.0[b]	13 (13)[b]	100/y[b]	NR	12[b]	3 (5)
Ma[53]	2018	NSCLC	Bone	RFA, CA	3.6	45 (76)	17 (68)	NR	12	2 (2.6)
Gardner[54]	2017	RCC	Bone	CA	3.4	40 (50)	41/50 (82)	31(77/y 26/5 y)	35	4 (8)
Erie[55]	2017	Prostate	MSK	RFA, CA	1.6	16 (18)	15 (83)	100/2 y	27	0
Aubry[24]	2017	Mixed	MSK	MWA	5.5	13 (16)	4 (36.3)	NR	12	0
Tomasian[41]	2016	Mixed	Spine	CA	NR	14 (31)	30 (96.7)	NR	10	0
Wallace[56]	2016	Mixed	Spine	RFA	NR	NR (55)	70/y	NR	7.9	0
Deschamps[57]	2014	Mixed	Bone	RFA, CA	NR	89 (122)	67/y	91/1	22.8	11 (9)
Welch[58]	2014	Renal	[c]	RFA, CA	NR	NR (46)	43 (93)	NR	22.5	0
McMenomy[59]	2013	Mixed	MSK	CA	2	40 (52)	45 (87)	91/y, 84/2 y	21	2 (5)
Bang[60]	2012	NSCLC	[c]	CA	3.1	8 (18)	17 (94)	NR	11	2 (11)
Bang[61]	2012	Renal	[c]	CA	3.7	27 (48)	47 (97)	NR	16	1 (2)

Moynagh et al. Semin Intervent Radiol 2018; 35(4):299-308

LATION FOR OLIGOMETASTATIC DISEA

McMenomy et al. Percutaneous cryoablation of musculoskeletal oligometastatic disease for complete remission



Oligometastatic patients (<5 lesions)
43 patients with MSK lesions
CWA

size and number of metastases
length of disease-free interval
Treatment adequacy of primary tumor
presence of multiple metastatic sites

Percutaneous Cryoablation of Musculoskeletal Oligometastatic Disease for Complete Remission

Brendan P. McMenomy, MD, A. Nicholas Kurup, MD, Geoffrey B. Johnson, MD, PhD, Rickey E. Carter, PhD, Robert R. McWilliams, MD, Svetomir N. Markovic, MD, PhD, Thomas D. Atwell, MD, Grant D. Schmit, MD, Jonathan M. Morris, MD, David A. Woodrum, MD, Adam J. Weisbrod, MD, Peter S. Rose, MD, and Matthew R. Callstrom, MD, PhD

JVIR 2013; 24:207

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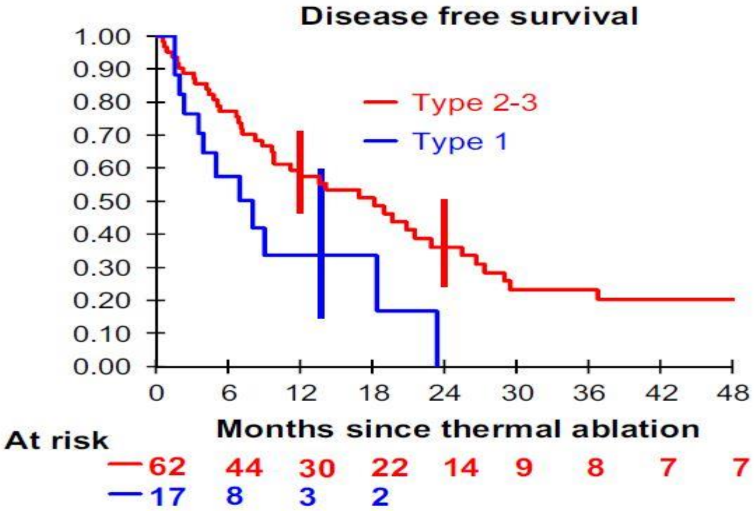
LATION FOR OLIGOMETASTATIC DISEA

ATTIKON

Barral et al F Percutaneous Thermal Ablation of Breast Cancer Metastases in Oligometastatic Patients



Oligometastatic patients (<5 lesions)
18/79 patients (23%) with bone lesions
RFA - CWA

PTA is associated with prolonged
OS, PFS, and local control of oligometastatic breast cancer regardless of the location of the metastases.
Increasing tumor burden (>4 cm) and triple-negative and histological subtype are significantly associated

Cardiovasc Intervent Radiol
DOI 10.1007/s00270-016-1301-x

CIRSE CrossMark

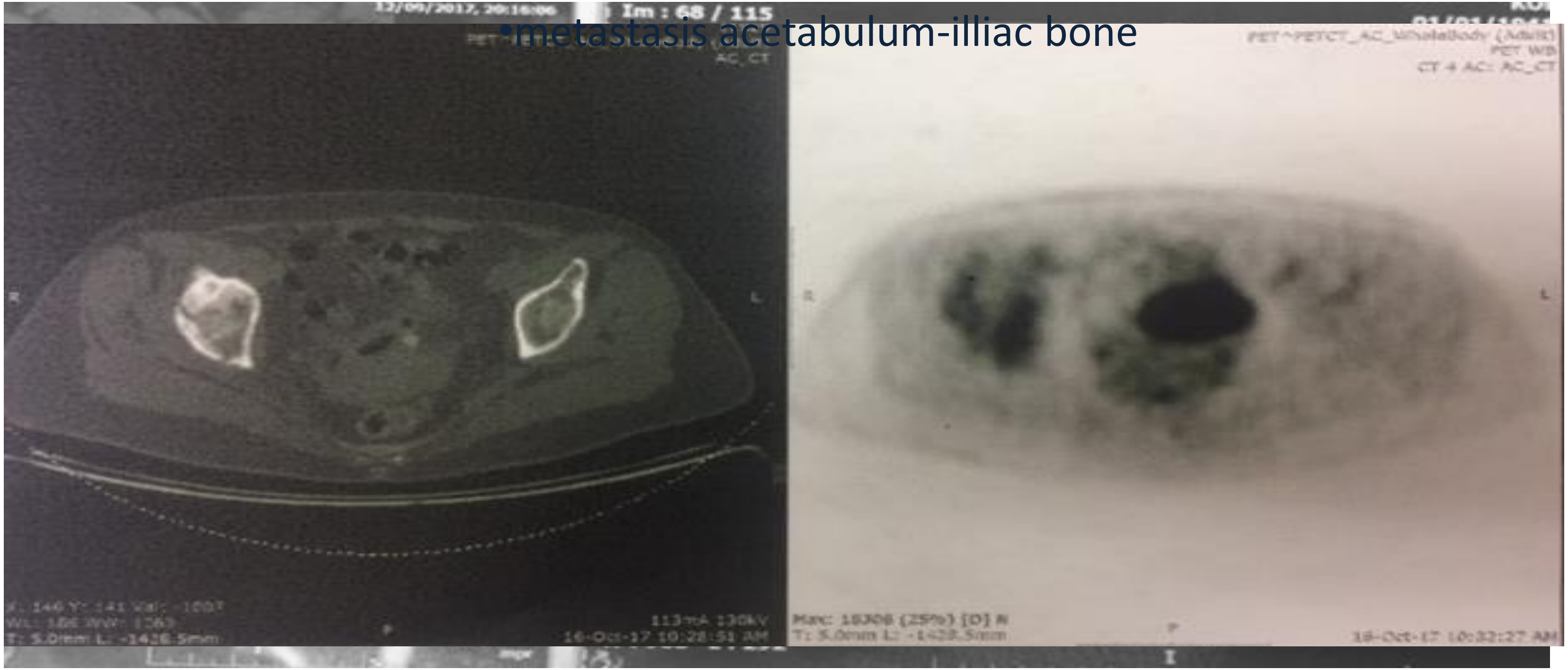
CLINICAL INVESTIGATION

Percutaneous Thermal Ablation of Breast Cancer Metastases in Oligometastatic Patients

M. Barral[1] · A. Auperin[2] · A. Hakime[1] · V. Cartier[1] · V. Tacher[1] · Yves Otmezguine[3] · L. Tselikas[1] · T. de Baere[1] · F. Deschamps[1]

ABLATION FOR OLIGOMETASTATIC DISEASE

- 59 y-o female
- Breast Ca
- metastasis acetabulum-illiac bone



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LATION FOR OLIGOMETASTATIC DISEA

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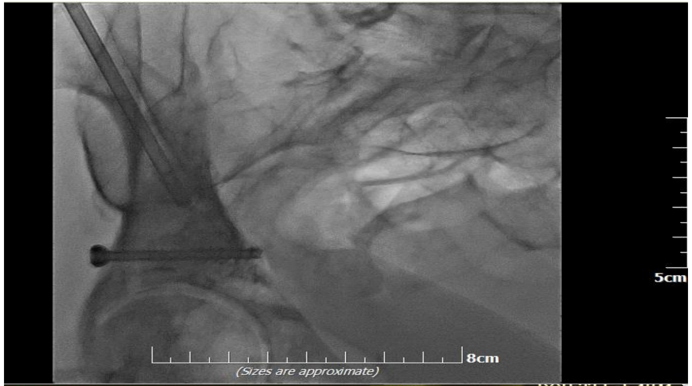
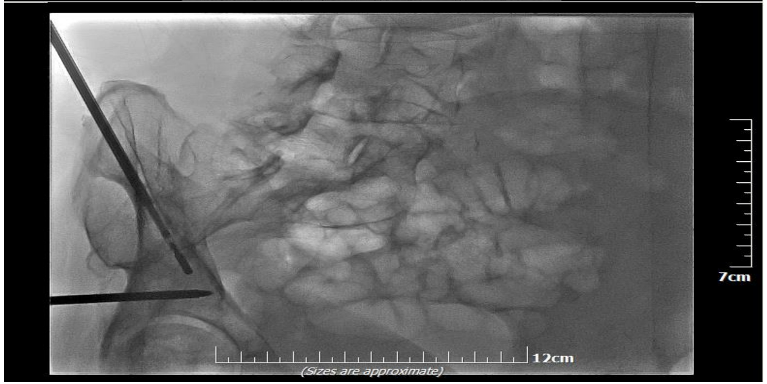
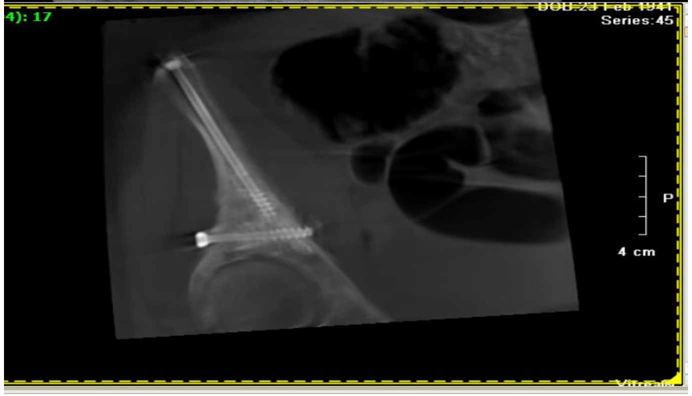
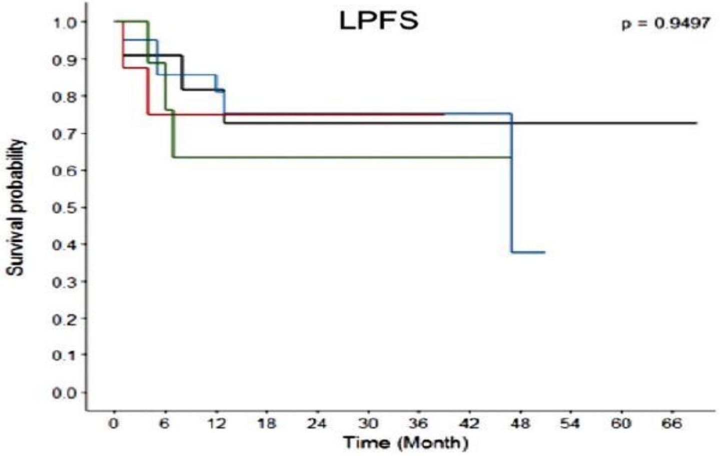






LATION FOR OLIGOMETASTATIC DISEA

Cazzato et al. Percutaneous image-guided ablation of bone metastases: local tumor control in oligometastatic patients



Number of patients at risk

	0	6	12	18	24	30	36	42	48	54	60	66
Thyroid	11	10	9	7	5	5	4	3	1	1	1	1
Breast	21	18	18	12	11	7	3	3	1	0	0	0
Lung	8	5	4	3	1	1	1	0	0	0	0	0
Others	9	7	4	3	2	1	1	1	0	0	0	0

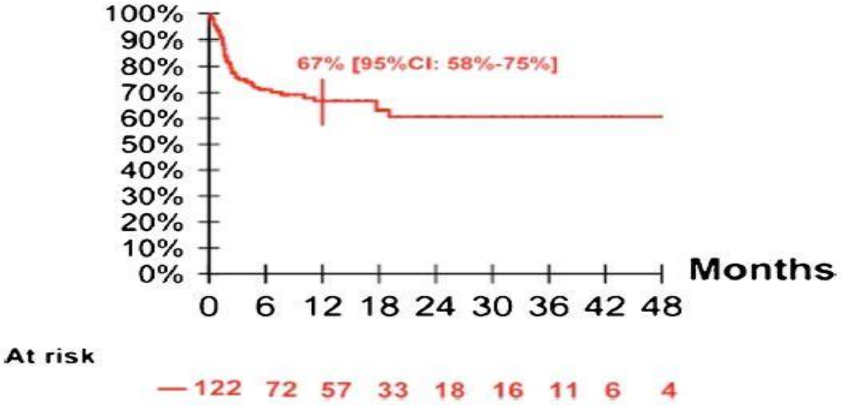
Oligometastatic patients (≤3 lesions)
46 patients – 49 lesions
Thyroid, Breast, Lung, Others
RFA – CWA (20% + consolidation)
34 mo fu
Lesion size >2cm predicted local tumor progression
Similar LPFS rates among all the different tumor histologies

Percutaneous image-guided ablation of bone metastases: local tumor control in oligometastatic patients

Roberto Luigi Cazzato, Pierre Auloge, Pierre De Marini, Chloé Rousseau, Jeanie Betsy Chiang, Guillaume Koch, Jean Caudrelier, Pramod Rao, Julien Garnon & Afshin Gangi

LATION FOR OLIGOMETASTATIC DISEA

Deschamps et al. Thermal ablation techniques: a curative treatment of bone metastases in selected patients?



Oligometastatic patients (≤3 lesions)
141 patients – 152 ablation sessions - 193 lesions
Thyroid, Breast, Kidney, Pheochromocytoma, Others
RFA – CWA (+ consolidation in weight bearing locations)
22.8 mo fu

Oligometastatic and/or metachronous diseases are good prognostic factors for local success
Small-size (<2 cm) bone metastases and no cortical erosion are good prognostic factors


European Radiology

Eur Radiol
DOI 10.1007/s00330-014-3202-1

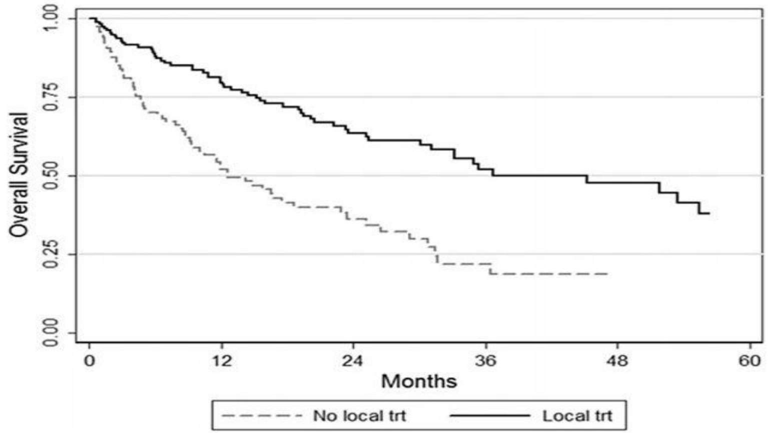
ONCOLOGY

Thermal ablation techniques: a curative treatment of bone metastases in selected patients?

F. Deschamps · G. Farouil · N. Ternes · A. Gaudin ·
A. Hakime · L. Tselikas · C. Teriitehau · E. Baudin ·
A. Auperin · T. de Baere

LATION FOR OLIGOMETASTATIC DISEA

Falk et al. Effect on Survival of Local Ablative Treatment of Metastases from Sarcomas: A Study of the French Sarcoma Group



Oligometastatic sarcoma patients (1-5 lesions)
281 patients, 164/281 patients received local treatment
35 (16.4%) RFA
25.7 mo fu

paradigm shift regarding the treatment of oligometastatic cancer
supports the evidence for sarcomas

Original Article

Effect on Survival of Local Ablative Treatment of Metastases from Sarcomas: A Study of the French Sarcoma Group

A.T. Falk [*], L. Moureau-Zabotto [†], M. Ouali [‡], N. Penel [§], A. Italiano [¶], J.-O. Bay [||**], T. Olivier [††], M.-P. Sunyach [‡‡], P. Boudou-Roquette [§§], S. Salas [¶¶], C. Le Maignan [|||], A. Ducassou [***], N. Isambert [†††], E. Kalbacher [‡‡‡], C. Pan [§§§], E. Saada [*], F. Bertucci [†], A. Thyss [*], J. Thariat [*] for the Groupe Sarcome Francais-Groupe D'etude Des Tumeurs Osseuses

LATION FOR OLIGOMETASTATIC DISEA

Vaswani et al. Radiographic Local Tumor Control and Pain Palliation of Sarcoma Metastases within the Musculoskeletal System with Percutaneous Thermal Ablation

Oligometastatic sarcoma patients (1-5 lesions)
local tumor control (17%; 11/64)
RFA or CWA
12 mo fu

Table 5 Cumulative local tumor control rates according to tumor histology at 3 months, 6 months, 9 months, and 1 year

	≥3 months	≥6 months	≥9 months	≥1 year	# with Oligometastatic disease
Epithelioid Hemangioendothelioma	93% (13/14)	93% (13/14)	92% (11/12)	92% (11/12)	9
Liposarcoma	100% (3/3)	100% (1/1)	–	–	1
Leiomyosarcoma	86% (6/7)	83% (5/6)	83% (5/6)	83% (5/6)	1
Angiosarcoma	100% (7/7)	100% (3/3)	100% (3/3)	100% (3/3)	
Osteosarcoma	67% (2/3)	0% (0/2)	0% (0/2)	0% (0/2)	
Ewing sarcoma	33% (1/3)	0% (0/3)	0% (0/3)	0% (0/3)	
Myxofibrosarcoma	100% (1/1)	–	–	–	1
Chondrosarcoma	100% (1/1)	0% (0/1)	0% (0/1)	0% (0/1)	
Synovial sarcoma	100% (1/1)	–	–	–	
No follow-up	24	10	3	0	

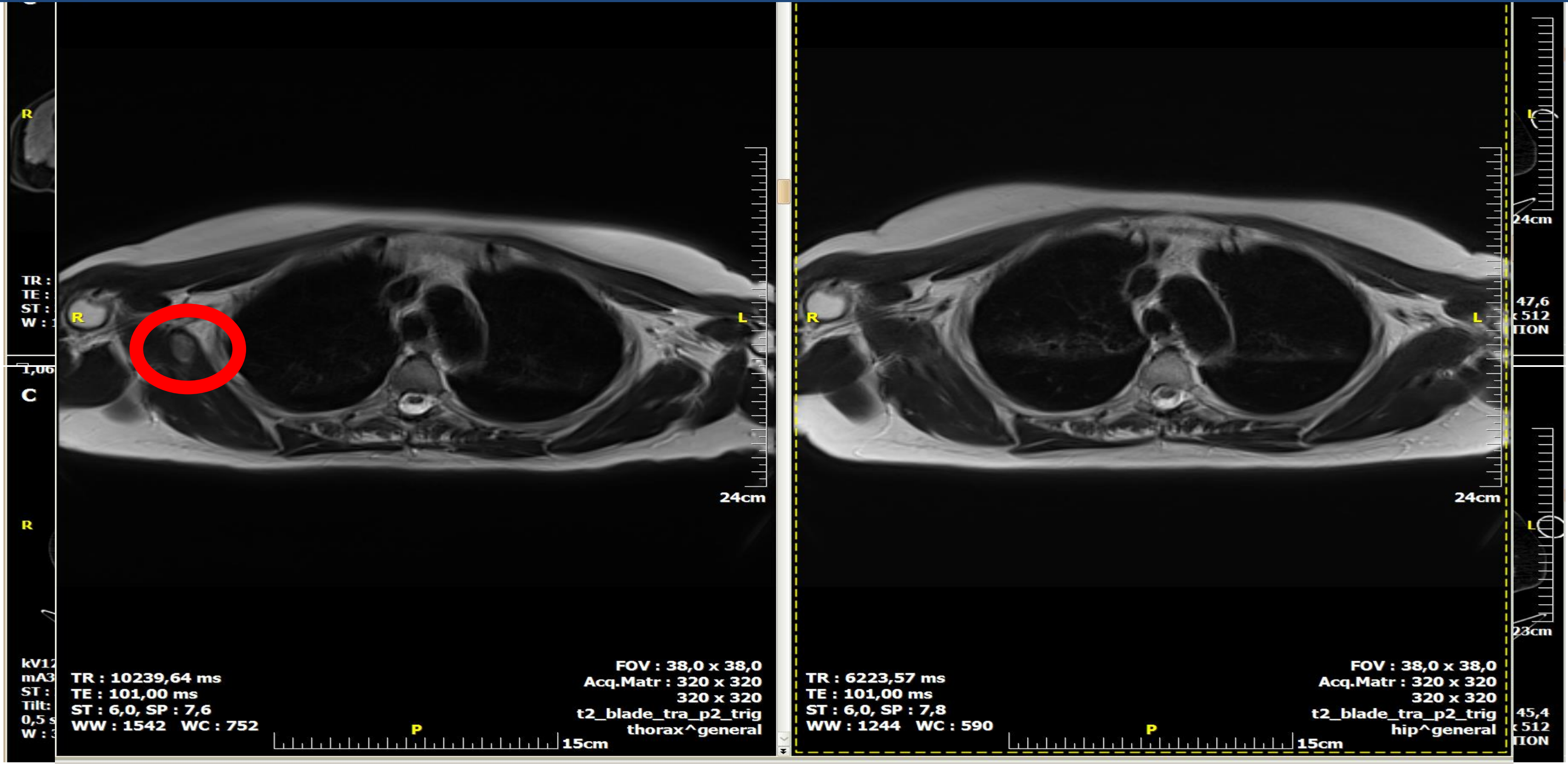
treatment in the setting of oligometastatic disease
offers potential for remission

Cardiovasc Intervent Radiol
https://doi.org/10.1007/s00270-018-1932-1
CIRSE CrossMark
CLINICAL INVESTIGATION

Radiographic Local Tumor Control and Pain Palliation of Sarcoma Metastases within the Musculoskeletal System with Percutaneous Thermal Ablation

Devin Vaswani[1] · Adam N. Wallace[1] · Preston S. Eiswirth[1] · Thomas P. Madaelil[1] · Randy O. Chang[2] · Anderanik Tomasian[3] · Jack W. Jennings[1]

LATION FOR OLIGOMETASTATIC DISEA



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LATION FOR OLIGOMETASTATIC DISEA

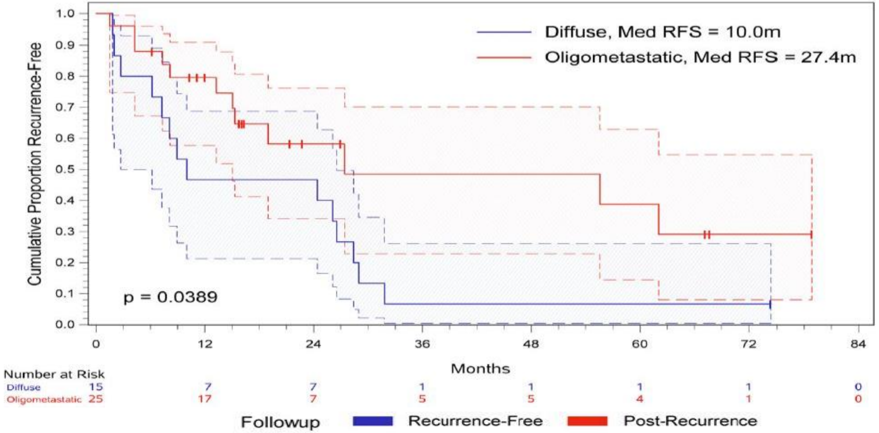
ATTIKON

Gardner et al. Cryoablation of Bone Metastases from Renal Cell Carcinoma for Local Tumor Control

40 patients – 50 bone meta

25/40 (62.5%) oligometastatic disease

CWA - 35 mo fu



Patients with oligometastatic disease experienced better local tumor control (96% [24 of 25]) compared with patients who had >5 metastases (53.3% [8 of 15]) (p = 0.001)

The local tumor-control rate was better for lesions for which a larger mean difference between maximum iceball diameter and maximum lesion diameter was achieved (2.2 ± 0.9 cm for those without recurrence versus 1.35 ± 1.2 cm for those with recurrence; p = 0.005).

1916

Cryoablation of Bone Metastases from Renal Cell Carcinoma for Local Tumor Control

Carly S. Gardner, MD, Joe E. Ensor, PhD, Kamran Ahrar, MD, Steven Y. Huang, MD, Sharjeel H. Sabir, MD, Nizar M. Tannir, MD, Valerae O. Lewis, MD, and Alda L. Tam, MD

Investigation performed at the University of Texas MD Anderson Cancer Center, Houston, Texas

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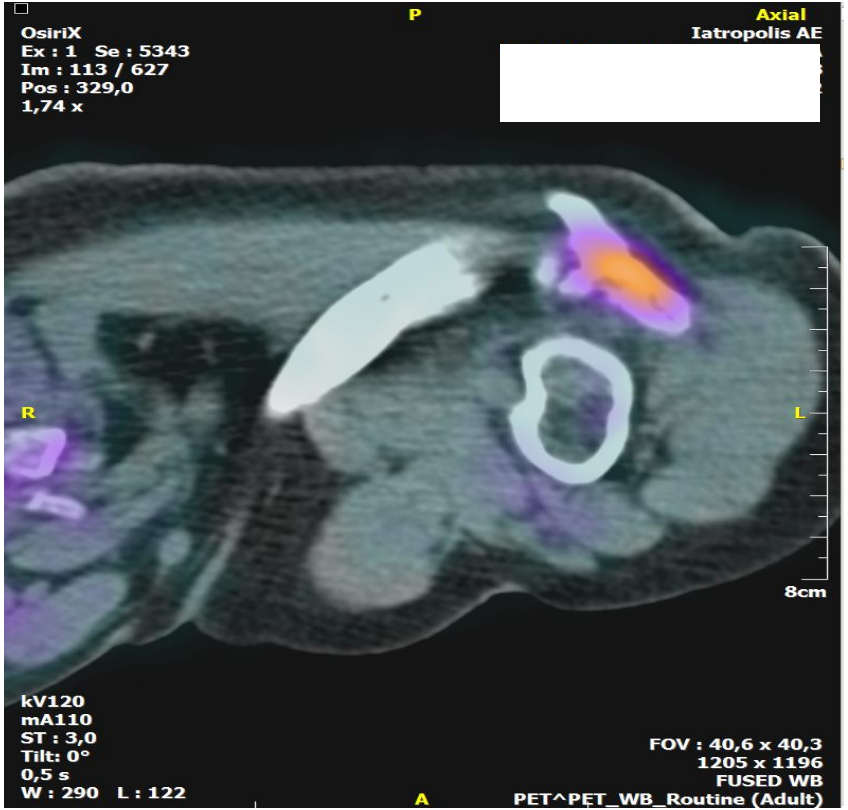

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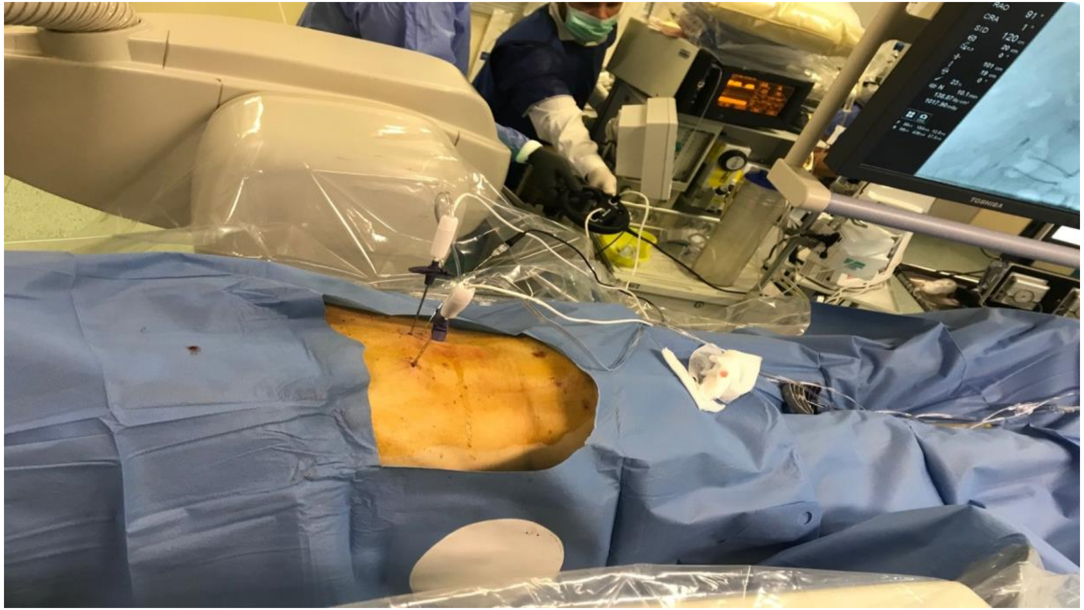

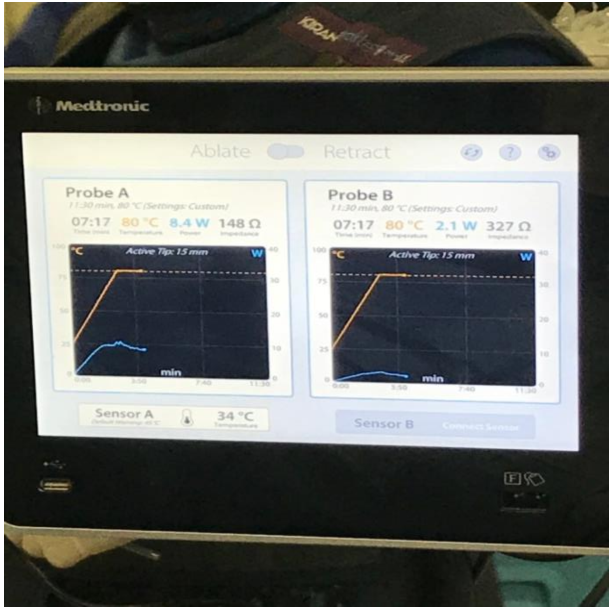

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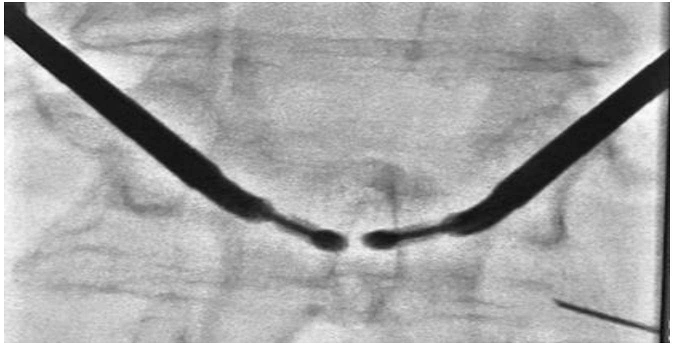
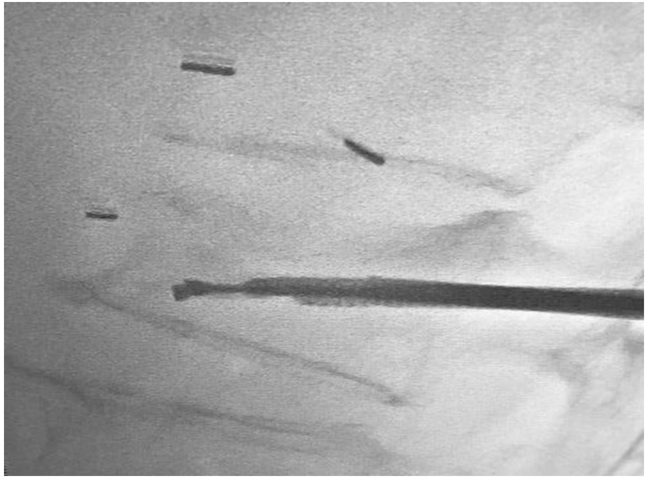
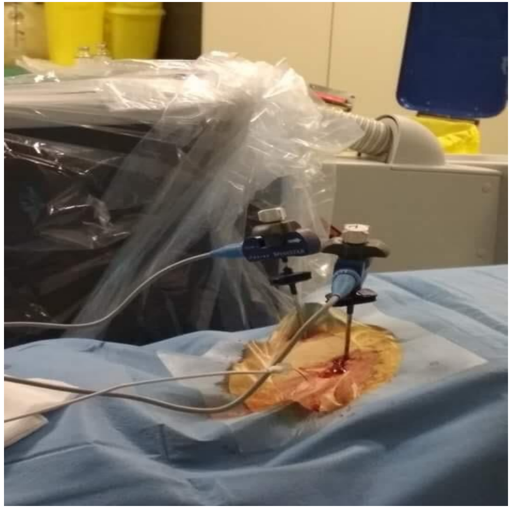


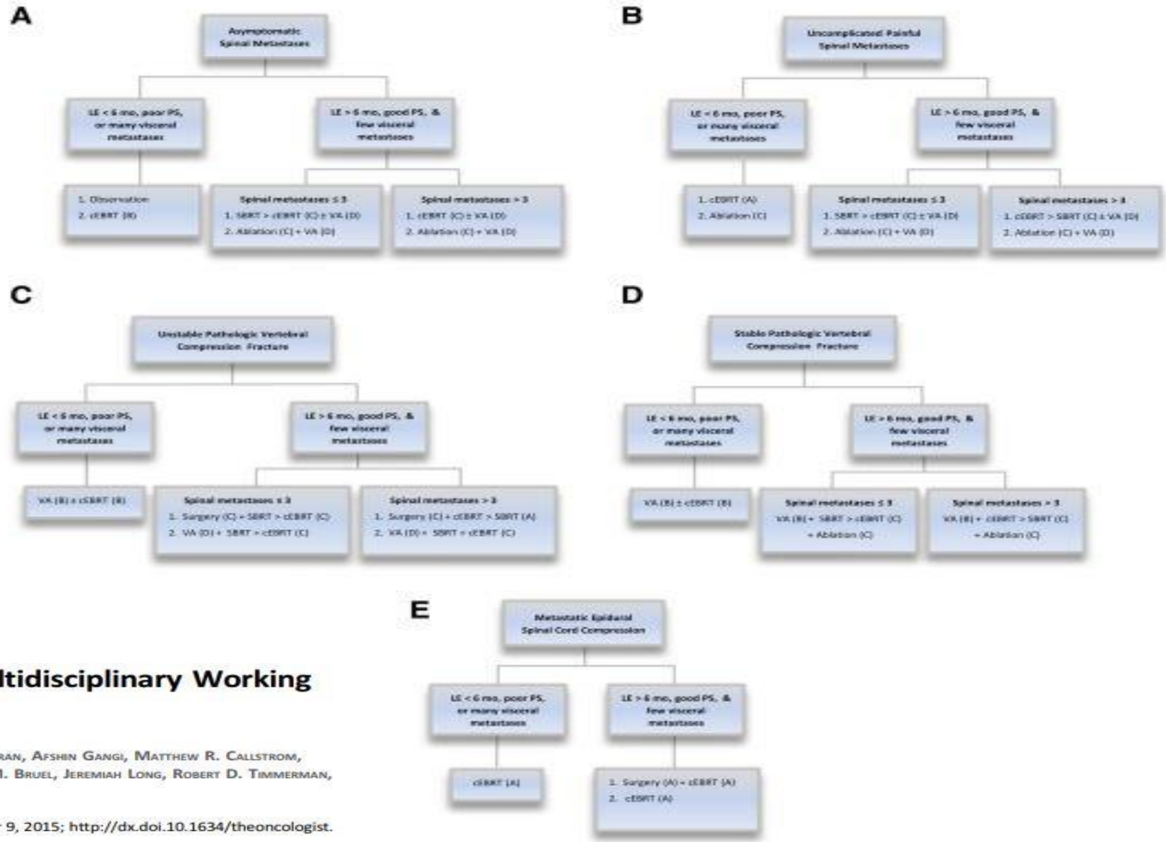




THERAPEUTIC ALGORITHM

- **Bone-only oligometastatic patients**
  - **Are we ready for curative ablation?**
  - **Is curative ablation ready for prime time?**
    - Access to RT modern equipment varies greatly throughout Europe
    - <1/3 of RTH centers are fully equipped for SBRT
      - Grau C et al Radiother Oncol. 2014;112(2):155- 64.
      - Bonet M et al Clinics in Oncology 2018

LATION FOR OLIGOMETASTATIC DISEA



The Metastatic Spine Disease Multidisciplinary Working Group Algorithms

Adam N. Wallace, Clifford G. Robinson, Jeffrey Meyer, Nam D. Tran, Afshin Gangi, Matthew R. Callstrom, Samuel T. Chao, Brian A. Van Tine, Jonathan M. Morris, Brian M. Bruel, Jeremiah Long, Robert D. Timmerman, Jacob M. Buchowski, Jack W. Jennings

The Oncologist 2015;20:1205–1215; first published on September 9, 2015; http://dx.doi.10.1634/theoncologist.2015-0085

THERAPEUTIC ALGORITHM

CURATIVE THERAPY (Oligometastatic disease)

- Spine → Ablation + Vertebral augmentation
- Peripheral Skeleton
  - Non-weight bearing area → Ablation
  - Weight bearing area → Ablation + bone augmentation

PALLIATIVE THERAPY

- Pain reduction
  - Spine → Vertebral augmentation
  - Peripheral Skeleton
    - Mirels Score<9
      - Non-weight bearing area → Ablation TAE
      - Weight bearing area → Ablation + bone augmentation
    - Mirels Score>9 → Ablation + bone augmentation
- Size reduction → Ablation TAE
- Tumor decompression
- Need for structural support → Bone augmentation + Ablation
- Asymptomatic Mirels score>9

Tokuhashi and Tomita systems
Mirels score
Karnofsky Performance Scale

FUTURE DIRECTIONS

- Multi-disciplinary (tumour board meetings)
- Multi-modality
- Combination of treatments
- REMEMBER:
  - THERE IS A NEED FOR A LOT MORE DATA
  - THERE IS A NEED FOR THERAPEUTIC ALGORITHM IN PERIPHERAL SKELETON

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PATIENT FOLLOW UP

RECIST vs mRECIST

Target lesions		
Response category	RECIST	mRECIST
CR	Disappearance of all target lesions	Disappearance of any intratumoral arterial enhancement in all target lesions
PR	At least a 30% decrease in the sum of the diameters of target lesions, taking as reference the baseline sum of the diameters of target lesions	At least a 30% decrease in the sum of the diameters of viable (enhancement in the arterial phase) target lesions, taking as reference the baseline sum of the diameters of target lesions
SD	Any cases that do not qualify for either PR or PD	Any cases that do not qualify for either PR or PD
PD	An increase of at least 20% in the sum of the diameters of target lesions, taking as reference the smallest sum of the diameters of target lesions recorded since treatment started	An increase of at least 20% in the sum of the diameters of viable (enhancing) target lesions, taking as reference the smallest sum of the diameters of viable (enhancing) target lesions recorded since treatment started
Non-target lesions		
Response category	RECIST	mRECIST
CR	Disappearance of all non-target lesions	Disappearance of any intratumoral arterial enhancement in all non-target lesions
IR/SD	Persistence of one or more non-target lesions	Persistence of intratumoral arterial enhancement in one or more non-target lesions
PD	Appearance of one or more new lesions and/or unequivocal progression of existing non-target lesions	Appearance of one or more new lesions and/or unequivocal progression of existing non-target lesions
mRECIST recommendations		
Pleural effusion and ascites	Cytopathologic confirmation of the neoplastic nature of any effusion that appears or worsens during treatment is required to declare PD.	
Porta hepatis lymph node	Lymph nodes detected at the porta hepatis can be considered malignant if the lymph node short axis is at least 2 cm.	
Portal vein thrombosis	Malignant portal vein thrombosis should be considered as a non-measurable lesion and thus included in the non-target lesion group.	
New lesion	A new lesion can be classified as HCC if its longest diameter is at least 1 cm and the enhancement pattern is typical for HCC. A lesion with atypical radiological pattern can be diagnosed as HCC by evidence of at least 1 cm interval growth.	

RECIST, Response Evaluation Criteria In Solid Tumors; mRECIST, modified Response Evaluation Criteria In Solid Tumors; CR, complete response; PR, partial response; IR, incomplete response; SD, stable disease; PD, progressive disease.
*Adapted from Llovet *et al.* [149] and Lencioni and Llovet [100].

Lencioni R, Llovet JM. Semin Liver Dis 2010;30:52–60
Llovet JM et al Journal of Hepatology 2012 vol. 56 j 908–943

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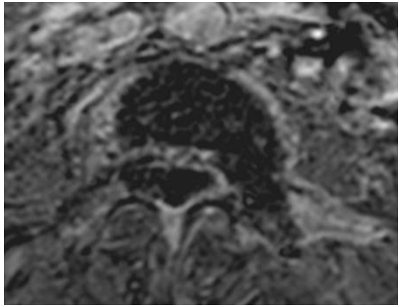
PATIENT FOLLOW UP

1 mo:

- Baseline MRI after treatment to allow post-ablation inflammation to subside (FAT-SAT+GD)

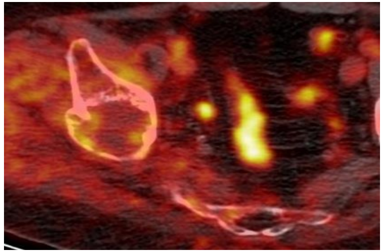


6-8 weeks:

- PET-CT scanning (requested by the oncologists) to evaluate systemic response, at which time evaluation of the ablated lesion can be performed

Subsequent imaging:

- At the discretion of the treating medical or surgical oncologist to assess for local tumor control
- When the patient complains of new or increasing pain at the site of ablation



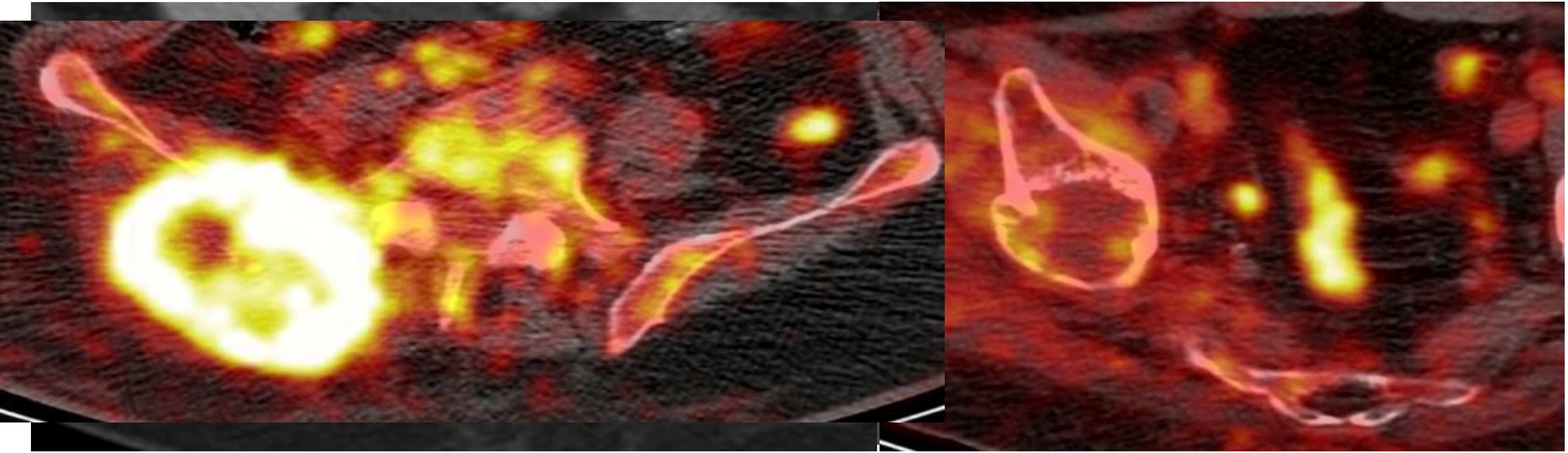
PATIENT FOLLOW UP

- [18F]-fluoro-2-deoxy-D-glucose (FDG)

- **Pre-procedural:** ability to detect tumors that are occult on conventional anatomic cross-sectional imaging and to identify metabolically active portions of tumors
- **Intra- procedural:**
  - the fusion of PET images obtained at the beginning of the procedure with CT images obtained intermittently during the procedure
  - fusion of intraprocedural CT images with pre-ablation PET
  - direct use of PET images for needle guidance
- **Post-ablation:** evaluate treatment adequacy, local tumor recurrence, and progression of musculoskeletal metastatic disease

Tomasian et al. PET Clin 2018; 13: 579–585

PATIENT FOLLOW UP



c/o A. Manca, Torino, ITALY

TAKE HOME MESSAGES……

- Metastatic substrate
  - esp. Prostate, Breast, Melanoma, RCC, NSCLC, Thyroid
  - Ca prostate: biochemical response
  - RCC: Increased survival
  - Breast Ca: subtype dependent – increased survival
  - Sarcoma: increased survival
- Lesion characteristics
  - Size <2cm
  - No cortical erosion
- Ablation technique ± structural augmentation

TAKE HOME MESSAGES……

- Uncertainty whether local therapy improves survival outcome or rather represents a selected population with better prognosis
- Criteria for appropriate application of ablation to limited metastases are not well established
- Understand timing and role of local treatment in MDT approach
- Appropriate case selection, thoughtful technique, proper fu

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Bone tumours: thermal ablation with or without consolidation

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Assistant Professor of Diagnostic and Interventional Radiology
2nd Department of Radiology, University General Hospital "ATTIKON"
Medical School, National and Kapodistrian University of Athens

INTERVENTIONAL STRATEGIES

Interventional consultation[1]
- Major indications for referral:
  - Pain likely to be relieved with nerve block (eg, pancreas/upper abdomen with celiac plexus block, lower abdomen with superior hypogastric plexus block, intercostal nerve)
  - Failure to achieve adequate analgesia and/or the presence of intolerable adverse effects (may be handled with intraspinal agents, blocks, spinal cord stimulation, or destructive neurosurgical procedures)

Current Oncology Reports (2019) 21:105
https://doi.org/10.1007/s11912-019-0844-9

PALLIATIVE MEDICINE (A JATOI, SECTION EDITOR)

Check for updates

The Role of Ablation in Cancer Pain Relief

Dimitrios K. Filippiadis[1] • Steven Yevich[2] • Frederic Deschamps[3] • Jack W. Jennings[4] • Sean Tutton[5] • Alexis Kelekis[1]

(ie, peripheral neuropathy, neuralgias, complex regional pain syndrome)
- Percutaneous ablation techniques for bone lesions
  - ◇ Specific therapies for bone pain are outside the scope of this guideline. Other resources (eg, Filippiadis 2019) may be referred to for more information

[1] Patient prognosis should be communicated to interventional pain colleagues as an important consideration when selecting interventional pain therapies.
[2] Infection, coagulopathy, very short life expectancy, distorted anatomy, patient unwillingness, medications that increase risk for bleeding (eg, anti-angiogenesis agents such as bevacizumab), or technical expertise is not available.

Note: All recommendations are category 2A unless otherwise indicated.
Clinical Trials: NCCN believes that the best management of any patient with cancer is in a clinical trial. Participation in clinical trials is especially encouraged.

BONE ABLATION

ISSUES TO CONSIDER PRIOR TO ABLATION:

- **CLINICAL**
- Local vs Diffuse bone pain
- "Mechanic" vs "Inflammatory" pain
- Performance status

- **TECHNICAL**
- Review recent cross sectional imaging (x rays, CT, MRI, PET/CT)
- Lesion shape / location / lytic vs blastic
- Impeding pathologic fracture (Mirels score, Harrington criteria, SINS)
- Vascularity
- Close by sensitive structures

A.N. Walace et al. The Oncologist 2015;20:1205–1215
Ratasvuori M et al. Surg Oncol 2013;22:132-138

BONE ABLATION

Radiofrequency (RFA)

Cryoablation (CWA)

Microwaves (MWA)

High Intensity Focused Ultrasound (HIFU)

- **Pain palliation ± functional restoration**
- Necrotize tumor-periosteum interface
- Tumor decompression
- Inflammation reduction
- Inhibition of osteoclast activity

Gangi et al Semin Intervent Radiol 2010 - Filippiadis et al Insights Into Imaging 2014
Rosenthal et al Radiology 2012 - Kurup et al Semin Intervent Radiol 2012

BONE ABLATION

Why to use:

- Minimally invasive approach
- Well-tolerated even in patients with co-morbidities or with extensive disease
- Overall morbidity of the procedure is low - impressive and reliable pain relief
- May assist in liquefying the tumor and allowing for better fill of the cement

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BONE ABLATION

The Role of Ablation in Cancer Pain Relief

Table 1 Recent studies applying ablation modalities for pain reduction in metastatic bone disease

Author (year)	Number of patients (Lesions)	Location	Tumor Substrate	Ablation Modality Used	Pain Reduction Score (NVS units)
Vaswani et al. (2018) [43]	41 (64)	Peripheral skeleton	Sarcoma	CWA or RFA	8 → 3
Ma et al. (2018) [44]	45 (76)	Peripheral skeleton	NSCLC	CWA or RFA	7.5 → 3.7
Deib et al. (2019) [45]	65 (77)	Peripheral skeleton	Metastatic disease of various substrate	MWA	6.32 → 2.01
Pusceddu et al. (2016) [46]	35 (37)	Peripheral skeleton	Metastatic disease of various substrate	MWA	6.8 → 0.7
Coupal et al. (2017) [47]	48 (48)	Pelvis	Metastatic disease of various substrate	CWA	7.9 → 1.2
Gallucher et al. (2019) [48]	16 (18)	Peripheral skeleton	Metastatic disease of various substrate	CWA	3.3 → 1.2
Cazzato et al. (2018) [49]	11(11)	Spine	Metastatic disease of various substrate	Bipolar RFA	7.8 → 3.5

Filippiadis et Curr Oncol Rep. 2019 25;21(12):105.

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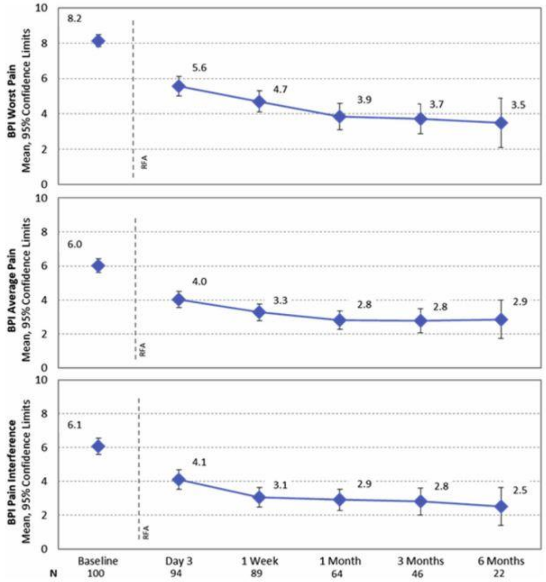
BONE ABLATION

Radiofrequency Ablation for the Palliative Treatment of Bone Metastases: Outcomes from the Multicenter OsteoCool Tumor Ablation Post-Market Study (OPuS One Study) in 100 Patients

100 patients (87-13 spine-sacrum/illium), 14 centers
97% of ablations were followed by cementoplasty
Variable neoplasmatic substrate
Mean worst pain score decreased from 8.2±1.7 at baseline to 3.5 ± 3.2 at 6 mo

Conclusions: Results from this study show rapid (within 3 d) and statistically significant pain improvement with sustained long-term relief through 6 mo in patients treated with RF ablation for metastatic bone disease.

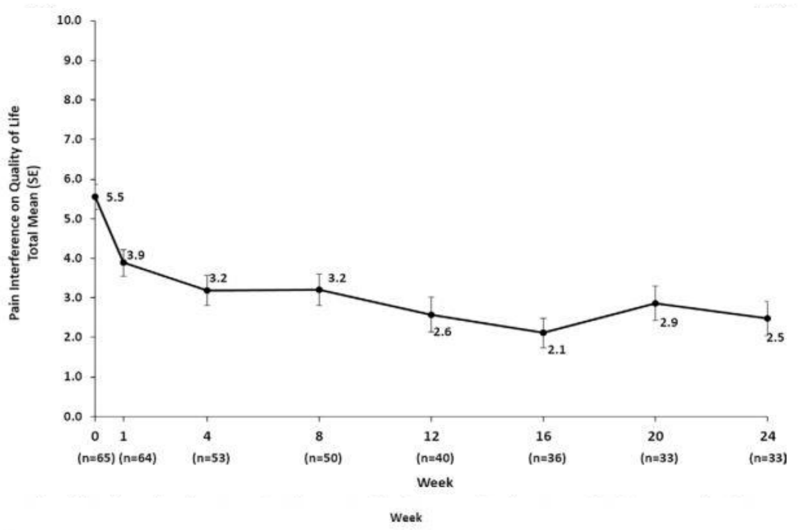


Levy et al J Vasc Interv Radiol . 2020 Nov;31(11):1745-1752.

BONE ABLATION

Cryoablation for Palliation of Painful Bone Metastases: The MOTION Multicenter Study

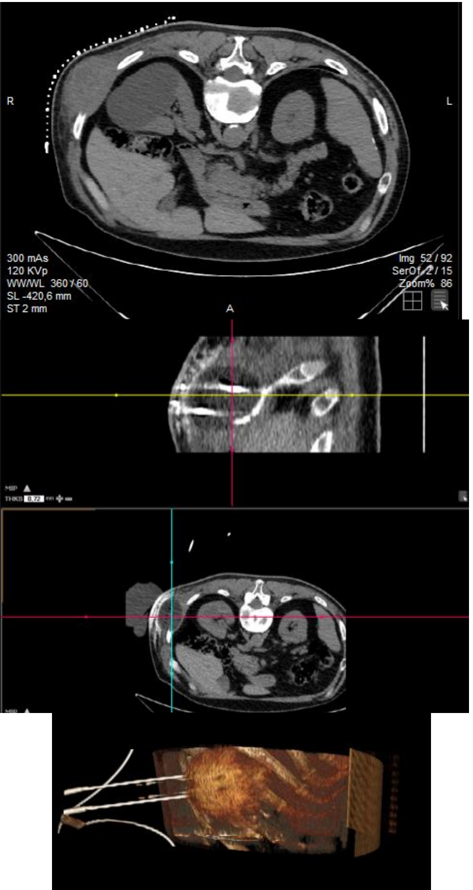
65 patients
Variable neoplasmatic substrate
Pain palliation – life quality improvement

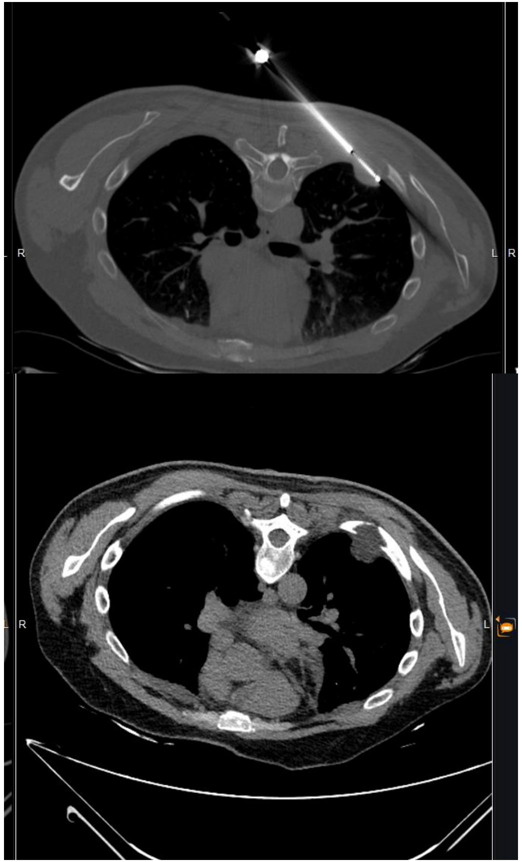


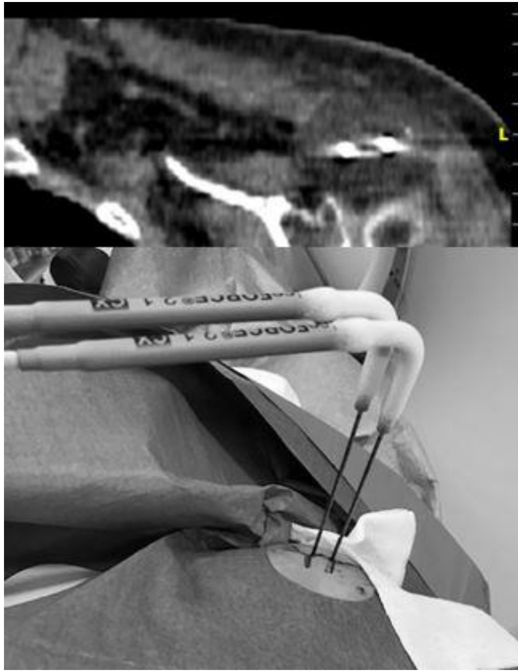
Conclusions: Cryoablation of metastatic bone tumors provided rapid and durable pain palliation, improved quality of life, and offered an alternative to opioids for pain control.

Jennings et al. Radiology: Imaging Cancer VOL. 3, NO. 2

BONE ABLATION







BONE ABLATION

Percutaneous microwave ablation of bone tumors: a systematic review

Seven non-comparative studies
249 patients and 306 tumors
Meta – myeloma - OO
Variable ablation protocols
4.0% clinically significant complications

Table 4 Pain reduction in studies reporting about malignant tumors

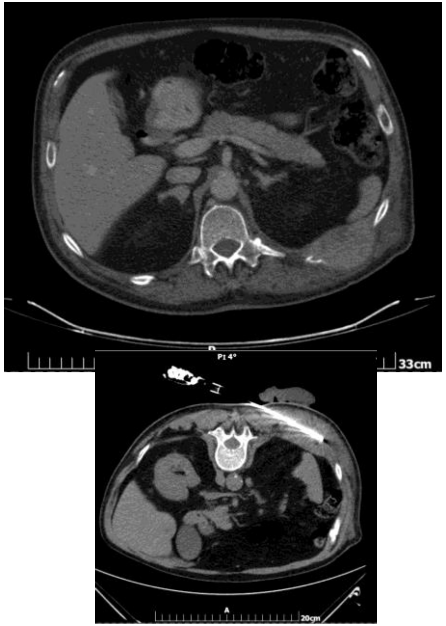
Study	Pain at 1 month				Pain at last recorded follow-up			
	Estimate	Standard Error	95% CI	Weight (%)	Estimate	Standard Error	95% CI	Weight (%)
Deib et al *AJR* (2019)	4.3	0.2	3.9–4.7	21.2	4.3	0.2	3.9–4.7	20.6
Pusceddu et al *CVIR* (2016)	6.1	0.3	5.5–6.6	20.4	6.6	0.2	6.1–7.1	20.3
Wei et al *Skel Radiol* (2015)	5.9	0.4	5.2–6.6	19.2	6.2	0.3	5.6–6.8	19.8
Khan et al *AJNR* (2018)	4.8	0.2	4.4–5.3	21.2	4.4	0.2	4.0–4.8	20.5
Kastler et al *JVIR* (2014)	5.7	0.4	4.9–5.4	18.0	5.1	0.4	4.3–5.9	18.9
Total (random effect)	5.3	0.4	4.6–6.1		5.3	0.5	4.3–6.3	

CI, confidence intervals

Conclusions: MWA is effective in achieving pain relief at short- (1 month) and mid-term (4-6 months) for painful OO and malignant bone tumors, respectively. Although MWA seems safe, further prospective studies are warranted to further assess this aspect, and to standardize MWA protocols.

Cazzato et al. Eur Radiol . 2020 Nov 6. Online ahead of print.

BONE ABLATION



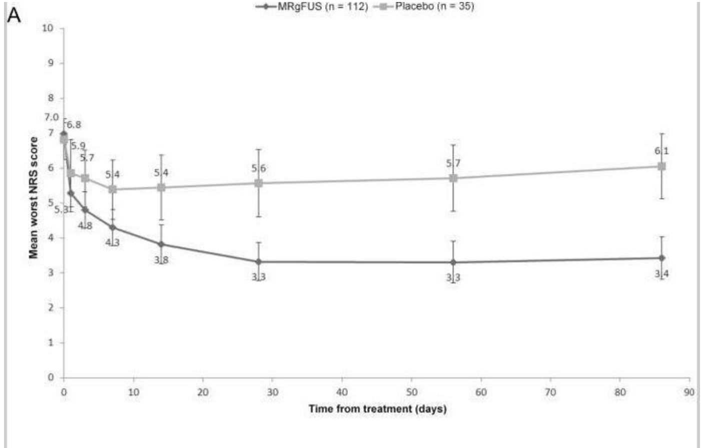
BONE ABLATION

Magnetic resonance-guided focused ultrasound for patients with painful bone metastases: phase III trial results

- 149 patients
- 112 (MR-guided HIFU)-35 (sham)
- Response rate for the primary endpoint:

  64.3% in the MRgFUS arm

  20.0% in the placebo arm ($P < .001$)



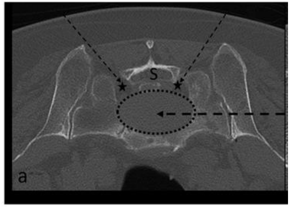
Conclusion: This multicenter phase III trial demonstrated that MRgFUS is a safe and effective, noninvasive treatment for alleviating pain resulting from bone metastases in patients that have failed standard treatments.

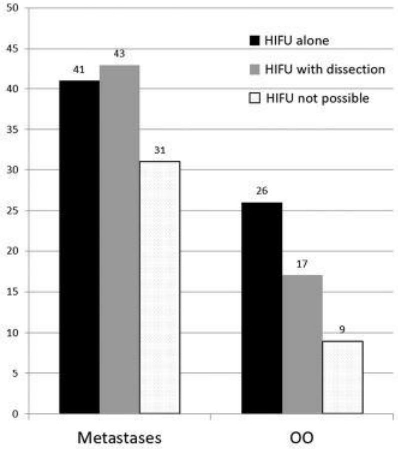
Hurwitz et J Natl Cancer Inst . 2014;106(5):dju082.

BONE ABLATION

Targetability of osteoid osteomas and bone metastases by MR-guided high intensity focused ultrasound (MRgHIFU)

- 115 metastatic lesions (43 pelvis)
  - HIFU may be performed alone
  - HIFU may be performed using protection of surrounding structures or bone consolidation
  - HIFU is not feasible





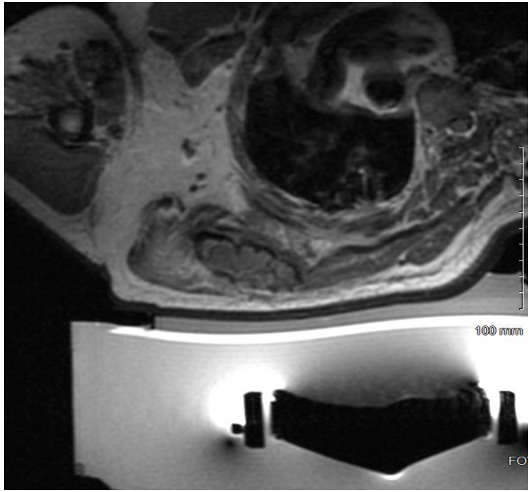
Conclusion: MRgHIFU cannot be systematically performed non-invasively on bone tumors. Combination with minimally-invasive thermo-protective techniques may increase the number of eligible cases.

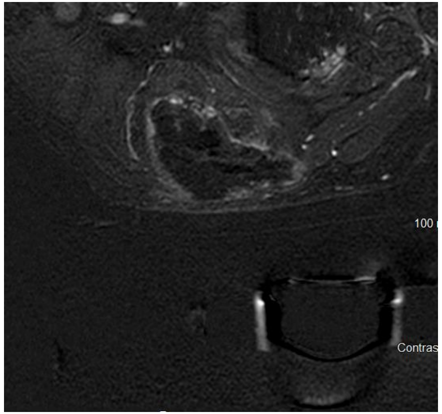
Bing et IJH 2018; 35(1):471-479

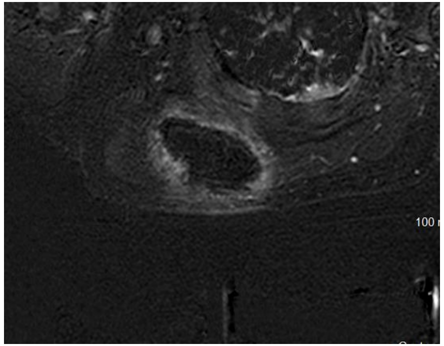
BONE ABLATION

- Recurrent disease in 2016

- MRgFUS Planning







c/o S. Tutton USA

BONE ABLATION

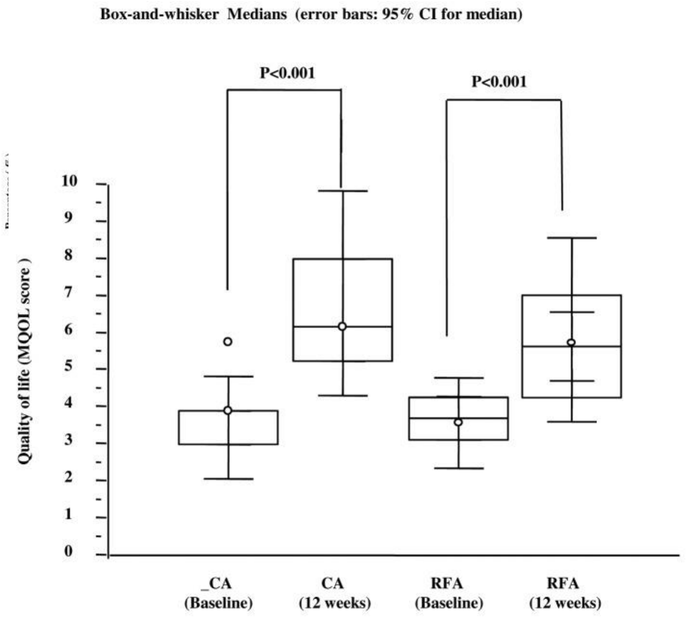
Randomized Ablation Trials

0

BONE ABLATION

Treatment of osteolytic solitary painful osseous metastases with radiofrequency ablation or cryoablation: A retrospective study by propensity analysis

50 patients (25/25 : RFA/CWA)
CA only significantly improves the rate of CR
CA only decreases the requirement of narcotic medications
A significant improvement in self-rated QoL was observed in both groups



Zugaro et al Oncol Lett. 2016 ; 11(3): 1948–1954.

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BONE ABLATION

Percutaneous image-guided thermal ablation of bone metastases: a retrospective propensity study comparing the safety profile of radiofrequency ablation and cryoablation

274 patients (53/221 : RFA/CWA)
similar rates of major complications with RFA and CA
higher rates of minor complications with RFA
due to preponderant post-procedural pain

Table 5. Analgesic protocol recently adopted at authors' institution.

Type of intervention	Bone tumor location	Management
Systemic multi-modal analgesia	All tumors	– Non-opioid drugs (paracetamol, NSAID, nefopam) – Opioids: – Tramadol for moderate pain – Morphine for severe pain
Central nerve block	From T10 to the feet	– Epidural injection of 5–10 ml Naropin 2%
Peripheral nerve block	Limbs	– Local injection 10–20 ml Naropin 2–7.5%

NSAID: non-steroidal anti-inflammatory drugs

Conclusions: Similar low rates of major complications are expected with RFA and CA of BM. In the post-operative period, RFA appears more painful than CA, thus warranting for adoption of dedicated analgesic protocols for patients undergoing RFA.

De Marini et al Int J Hyperthermia . 2020;37(1):1386-1394.

BONE ABLATION

Complications Following Percutaneous Image-guided Radiofrequency Ablation of Bone Tumors: A 10-year Dual-Center Experience

- 169 patients (48.8% pelvis)
- major complication rate was 2.3%
- most frequent event: secondary fracture
- immediate postoperative pain 18%

Risk factors for complications are tumor size greater than 3 cm and previous radiation therapy

Cazzato et al Radiology 2020;296(1):227-235

Complications of Percutaneous Bone Tumor Cryoablation: A 10-year Experience

- 239 patients – 320 lesions
- major complication rate was 2.5%
- secondary fracture 1.2%

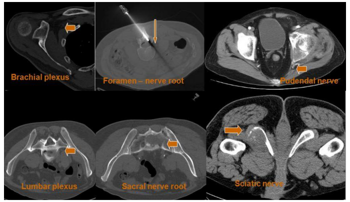
Major complications are associated with age >70 years
and use of more than three cryoprobes

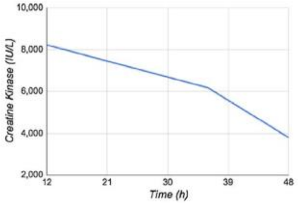
Cazzato et al Radiology 2019;291(2):521-528.

BONE ABLATION

Avoiding Complications:

- Neural injury
- Applicator placement - damage
- Fracture risk
- Inadvertent osteochondral injury
- Large tumor treatment and tumor lysis



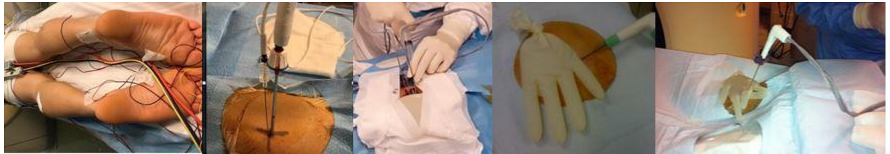


Kurup et al Cardiovasc Intervent Radiol 2017;40(2):166-176

- **Passive thermal protection**
  - Thermocouples
  - Intra-operative neurological monitoring systems

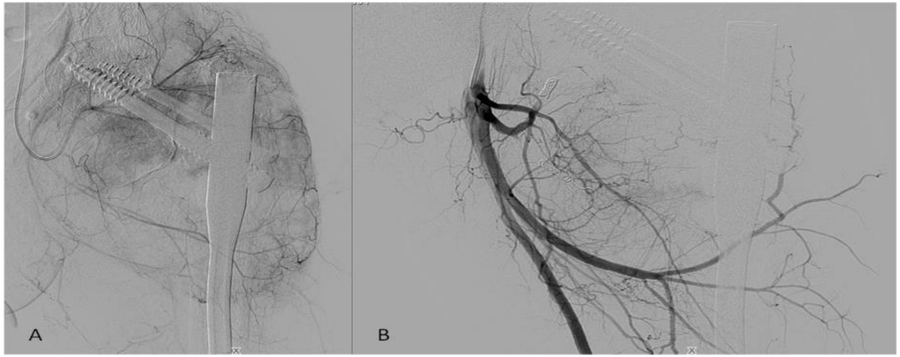
  (neurodiagnostic EEG, EMG and evoked potential electrodes and accessories, electrostimulation of peripheral nerves)
- **Active thermal protection - insulation**
  - CO_2, - air
  - Hydrodissection
  - Skin warming/cooling

Tsoumakidou et al CVIR 2013
Filippiadis et al Insights Imaging 201
Kurup et al CVIR 2017

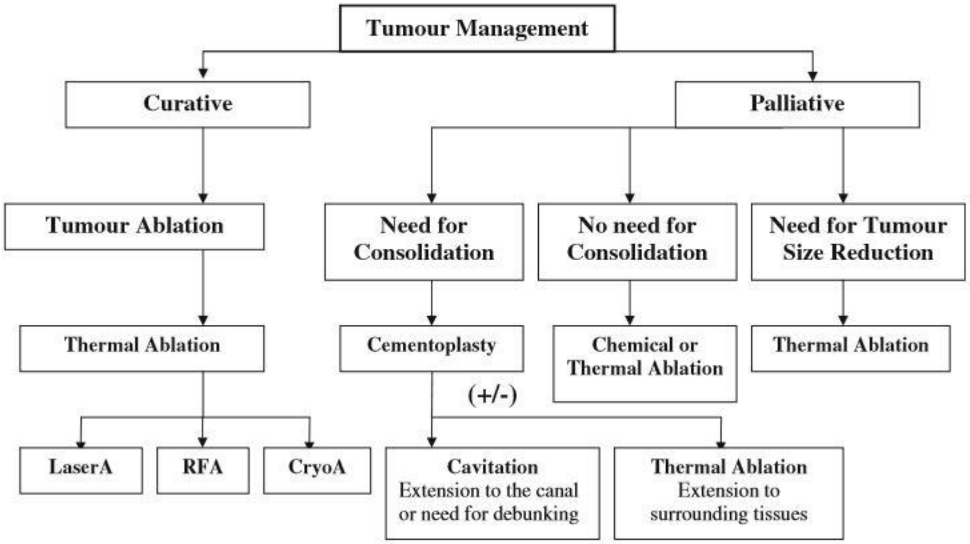


BONE ABLATION

Ablation + surgery
Ablation + RTH
Ablation + TAE
Ablation + Osseous augmentation
Ablation +Cementoplasty + embolization



BONE ABLATION



- Clinical presentation (no symptoms vs mechanic pain)
- Localization, size, type of the lesion
- Associated destruction of bony cortex
- Previous local therapies
- Presence of pathological fracture

Gangi et al Cardiovasc Intervent Radiol 2010; 33:706–713

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BONE ABLATION

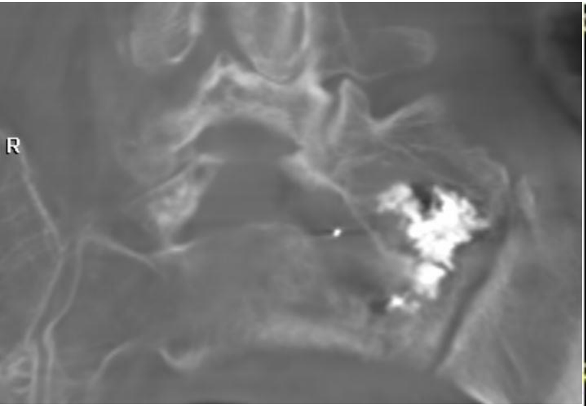
Table 1 Included studies and procedure details.

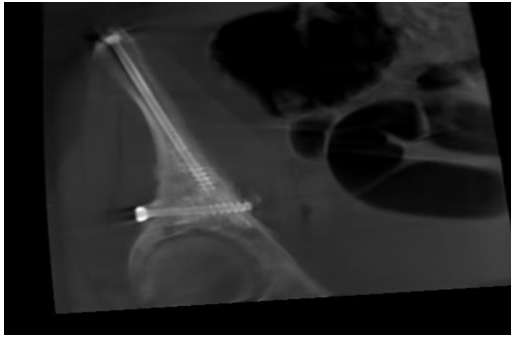
References	Authors	Main indication for PC	No of patients	No of lesions in the pelvic bone	No of lesions in the long bones	No of lesions in other locations	Additional treatment combined with PC	Needle diameter (G)	Mean volume of injected cement (mL)	Maximal volume of cement (mL)
[7]	Couraud et al.	Pain 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

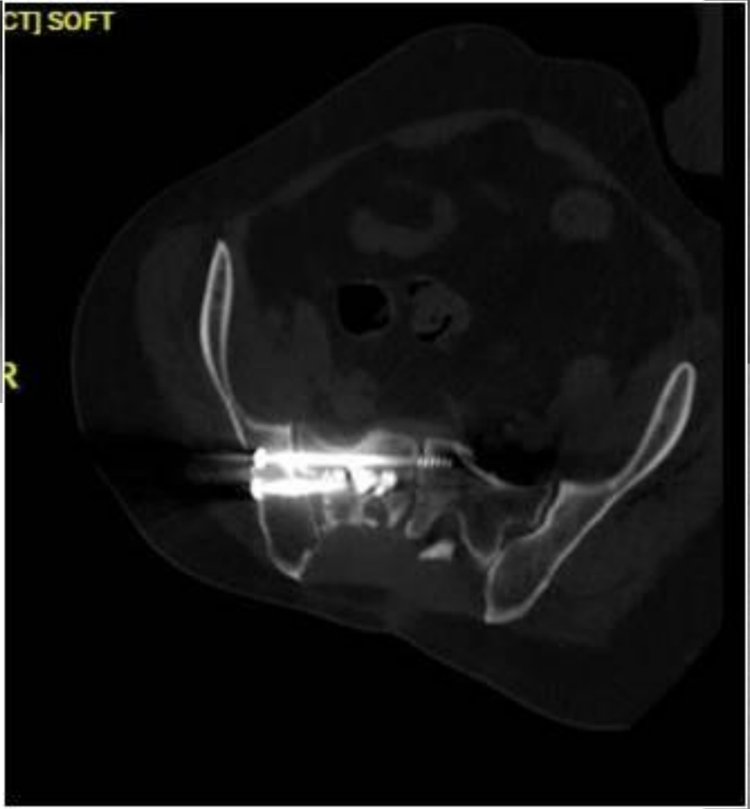
No: number; PC: percutaneous cementoplasty; G: gauge; N.R.: not reported; RFA: radiofrequency ablation; MWA: microwave ablation.

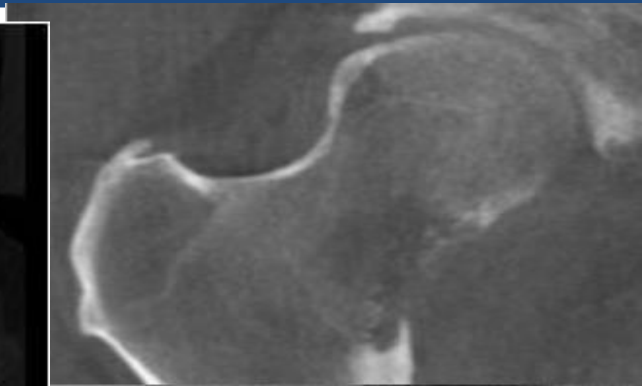
Garnon et al DII 2019; 100(12):743-752

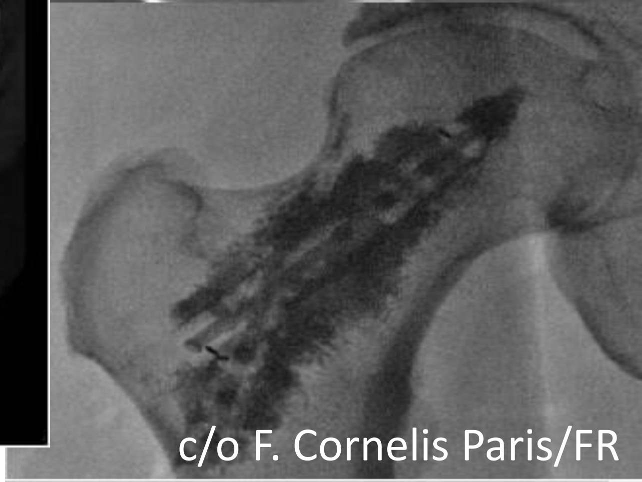
BONE ABLATION





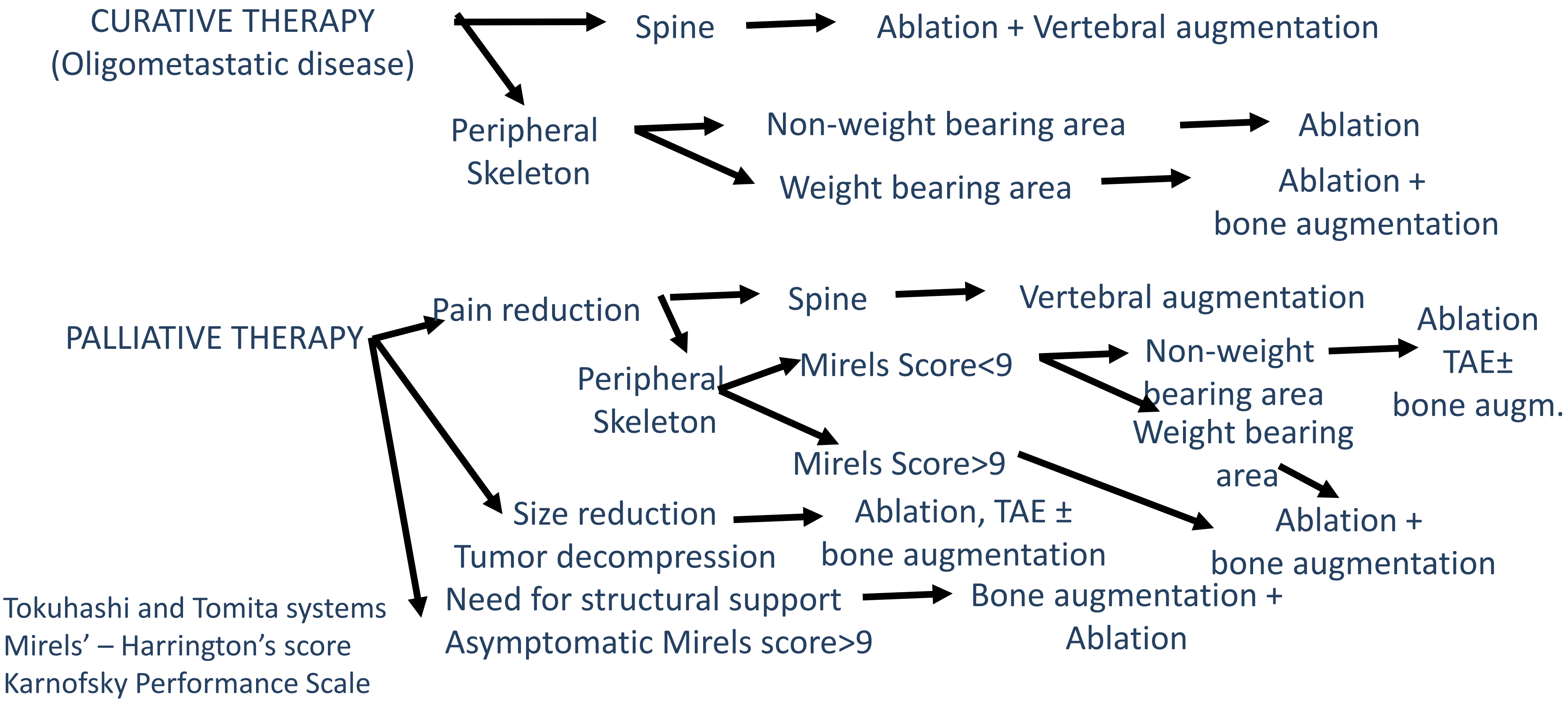






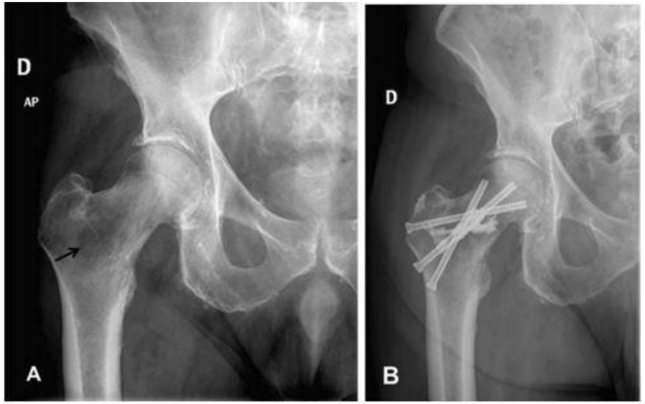
c/o F. Cornelis Paris/FR

PELVIC BONE ABLATION



BONE ABLATION

Tumoral dissemination along the screw trajectory in percutaneous osteosynthesis and cementoplasty: a non-described complication



Conclusions: Although we present no direct supportive evidence, the development of a coaxial system and possibly a percutaneous ablation strategy associated with POC should be considered, especially in patients with longer life expectancy.

Gjorgjievska Delov et al CVIR. 2018; 41:336–339

TAKE HOME.......

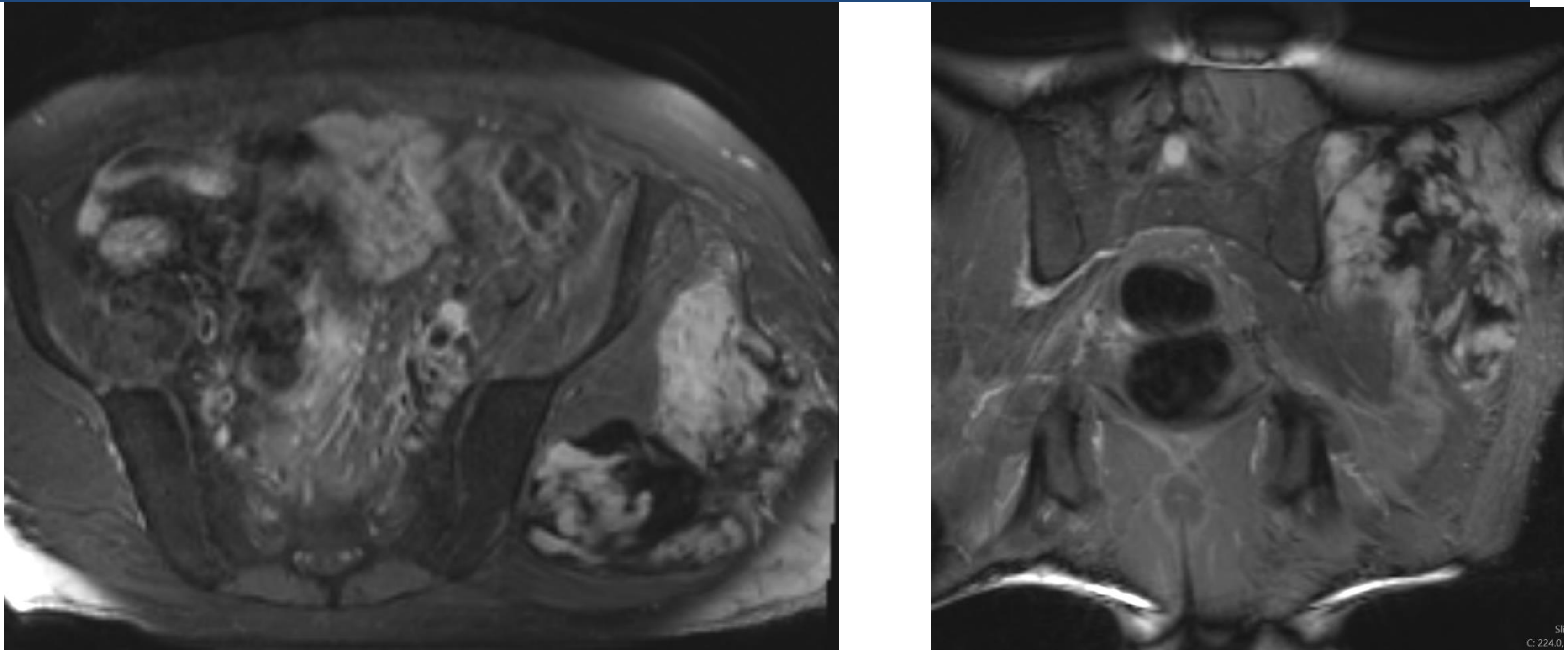
- **BONE ABLATION CONCERNS**
- Access to the lesion
- Extent of ablation zone
- Protection of surrounding sensitive structures (nerves, joints, skin etc)
- Large sized tumors (technically challenging - myoglobinuria)
- Combo treatments (osseous augmentation, TAE)

TAKE HOME.......

- **BONE ABLATION**
- Feasible, safe and efficacious technique aiming for pain palliation ± functional restoration
- Included in the NCCN Guidelines for Adult Cancer Pain

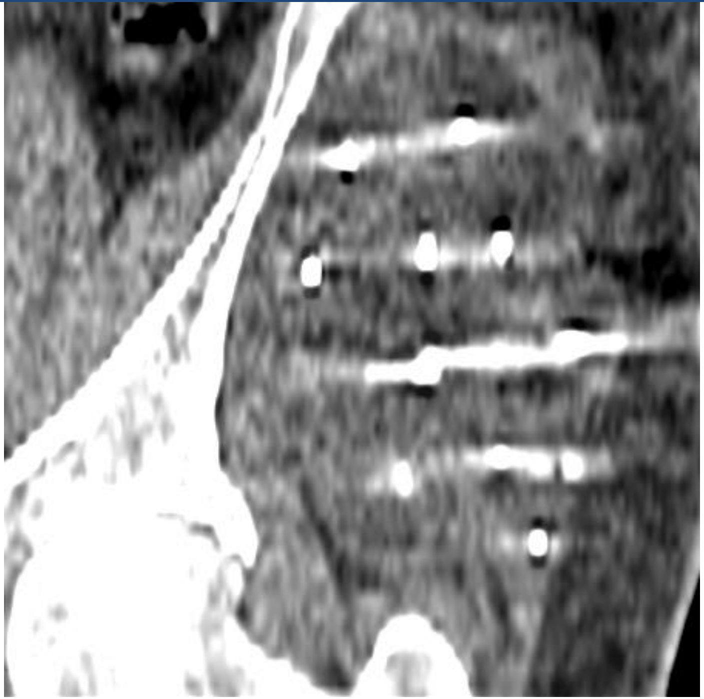
- Multiple ablation techniques available
- Optimize selection: patient (lesion) tailored approach to maximize efficacy

DESMOIDS



48 yom with painful left gluteal desmoid tumor

DESMOIDS



First ablation (12 probes)

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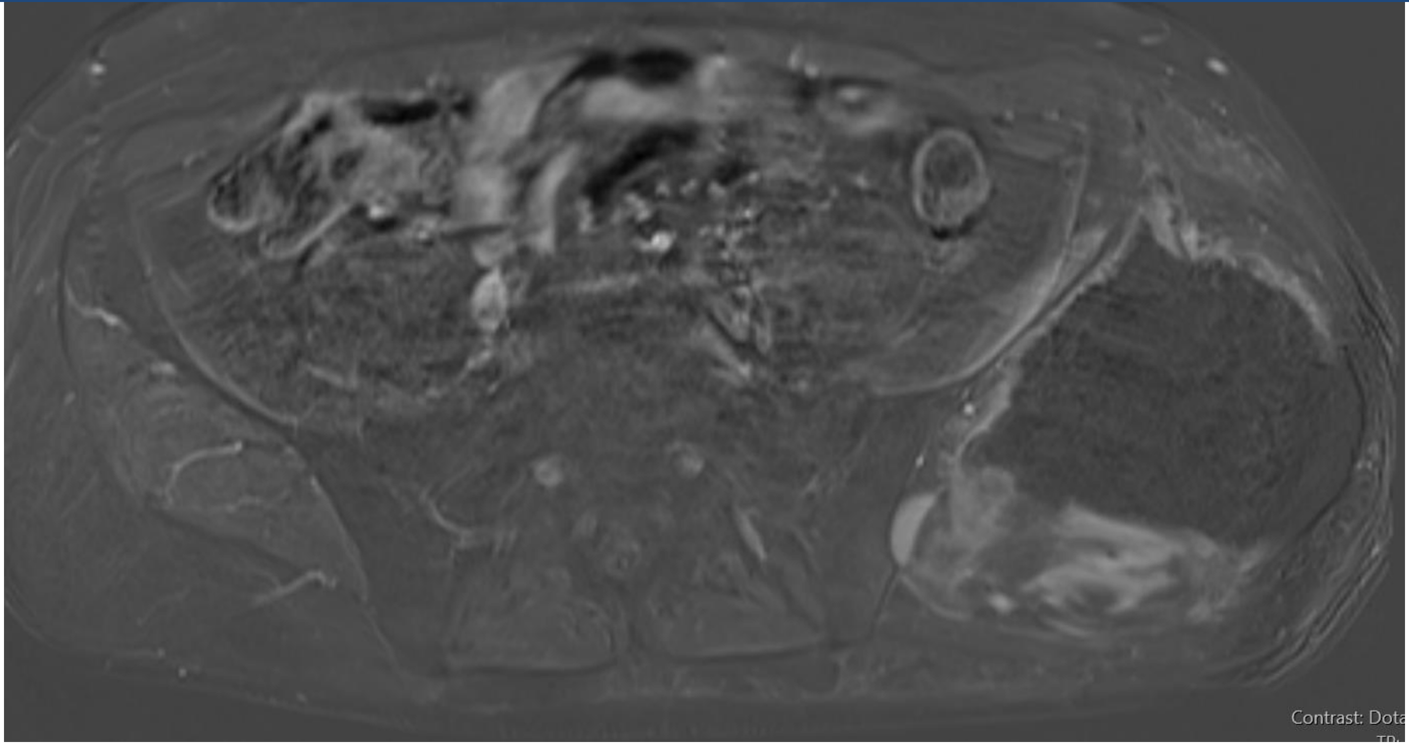
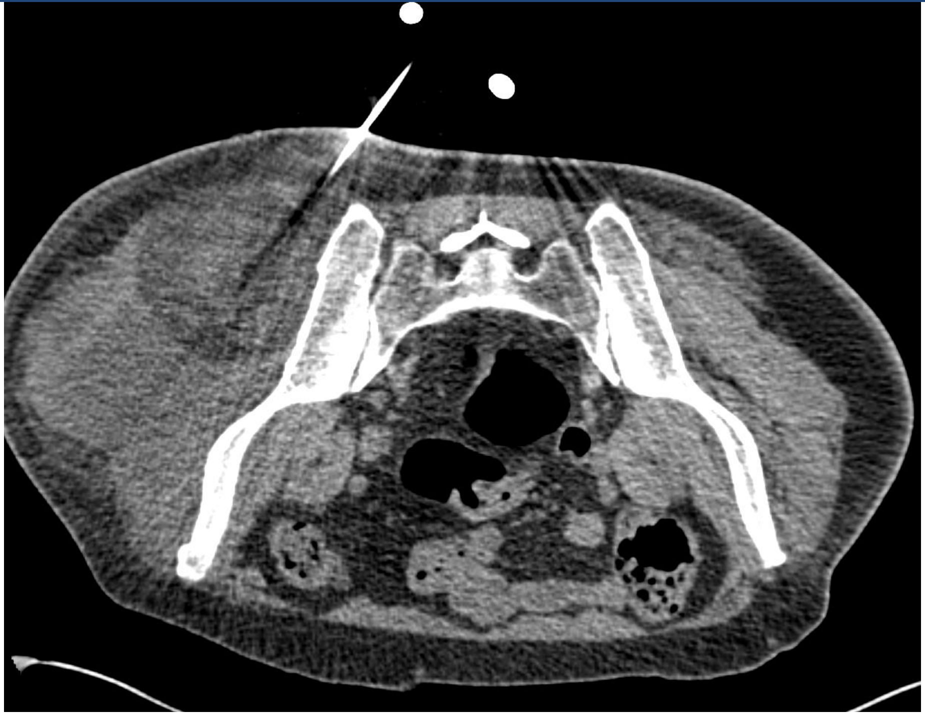
DESMOIDS



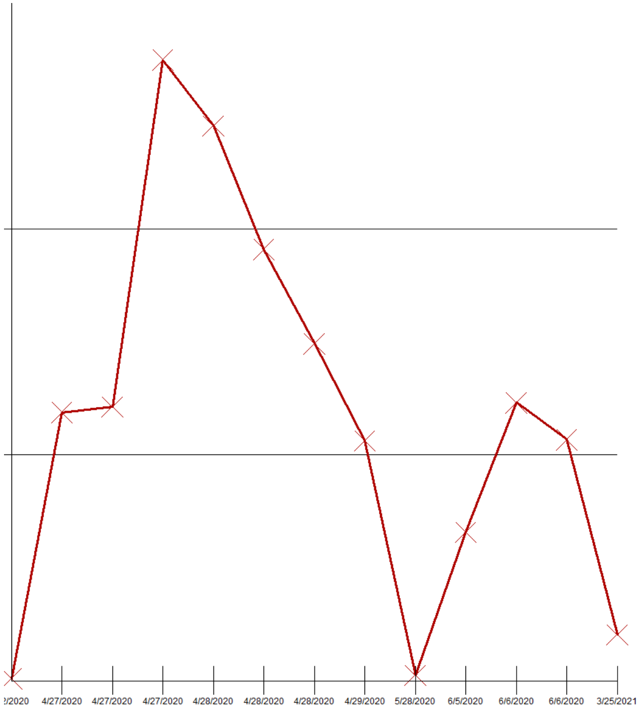
First ablation Post MRI (T1FS subtraction images)

DESMOIDS



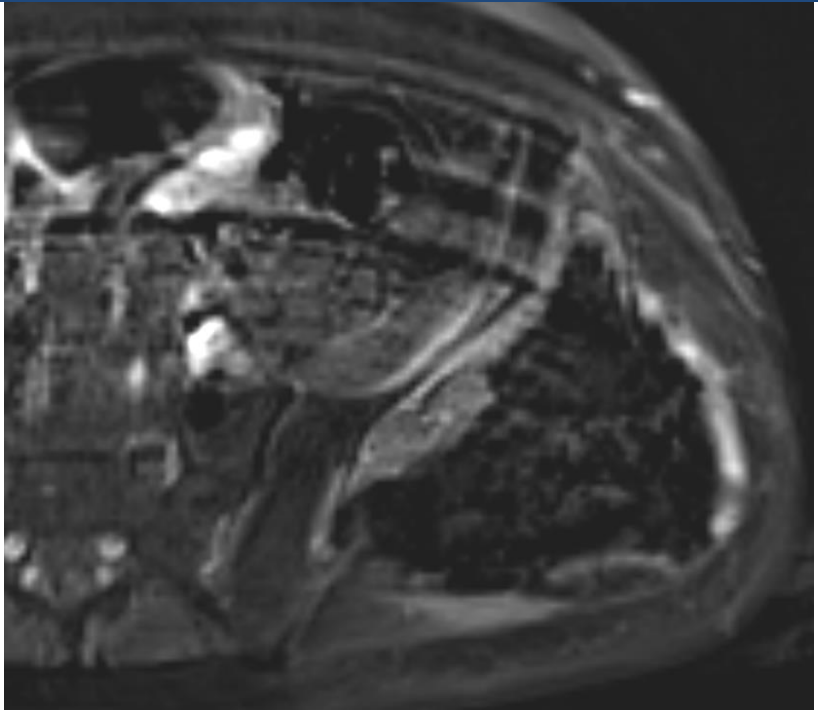
Second ablation (10 probes)

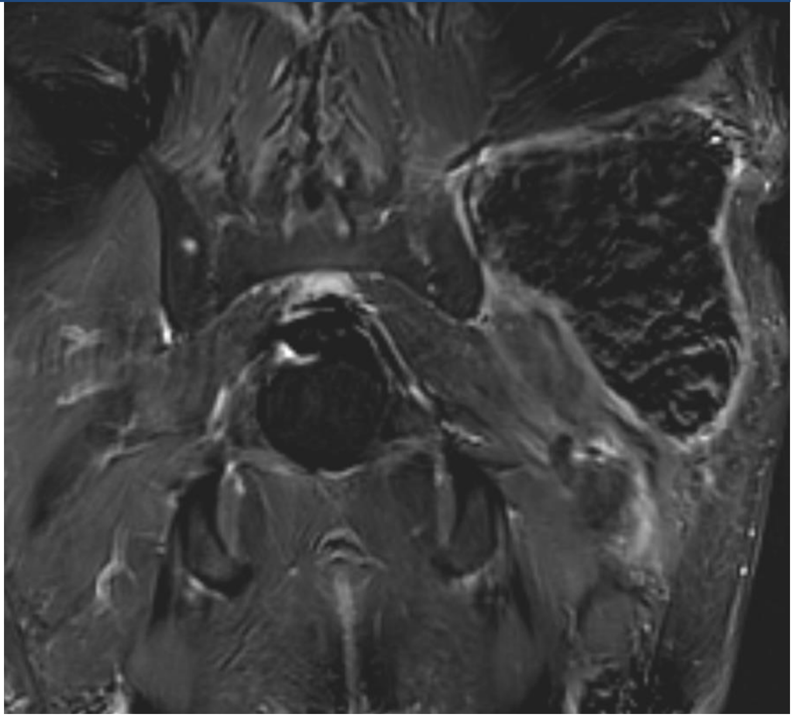
DESMOIDS



CK elevation with rhabdomyolysis (planned admission for IV fluids and Cr and CK monitoring)

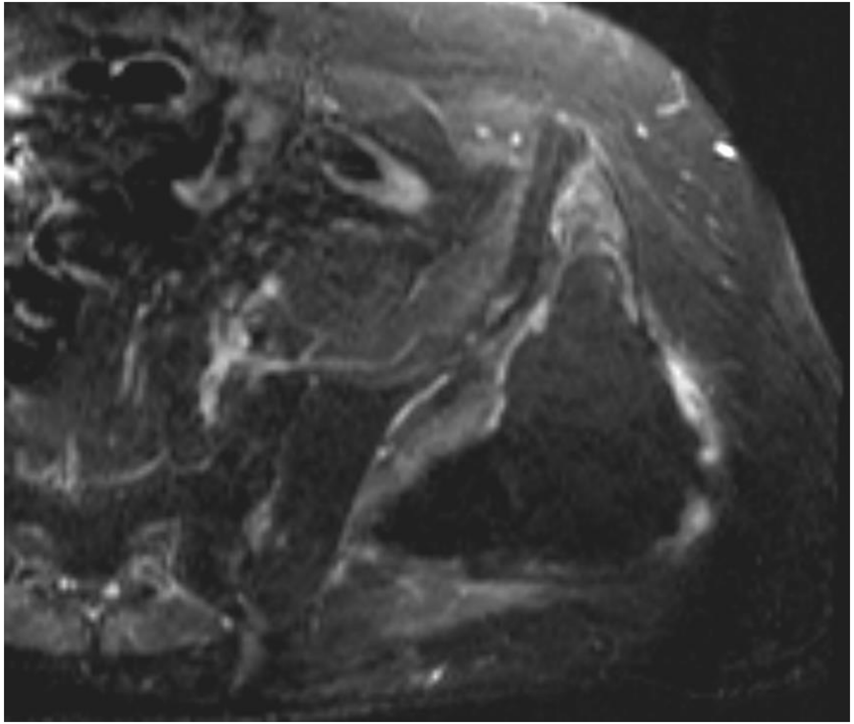
DESMOIDS

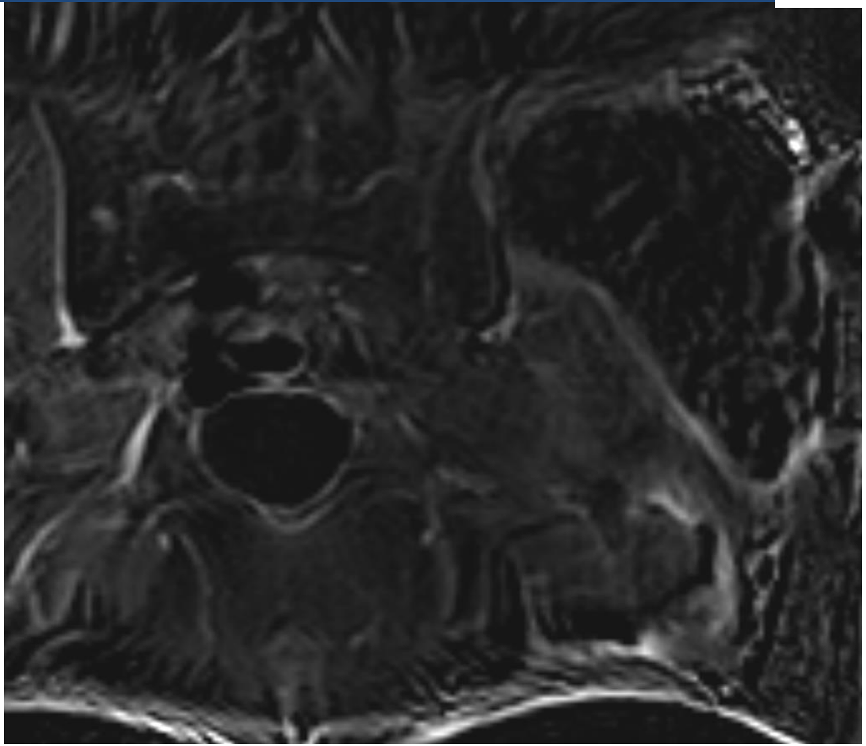




Post Second ablation 4 mos

DESMOIDS





Post Second ablation 10 mos

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MUSCULOSKELETAL AND SPINE (MSK) MASTERCLASS

Cementoplasty with or without ablation

Dimitrios K Filippiadis MD, PhD, MSc, EBIR
Assistant Professor of Diagnostic and Interventional Radiology
2nd Radiology Dpt, University General Hospital "ATTIKON"
Medical School, National and Kapodistrian University of Athens

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CANCER PAIN

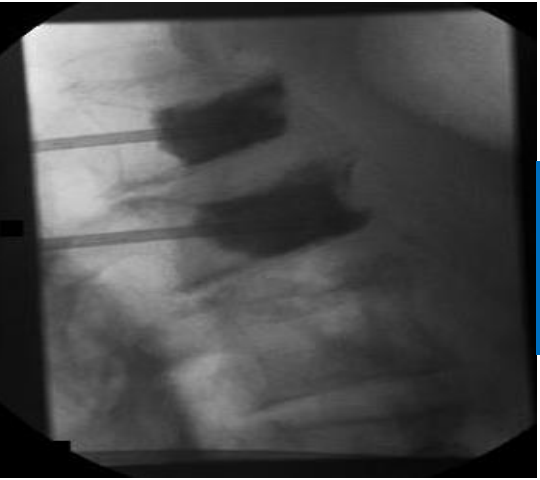
- Lytic metastases cause MSK pain by:

  - undermining osseous stability and the integrity of muscle and tendon insertions
  - causing increased intraosseous pressure and exerting periosteal stretching
  - compressing adjacent nerves and muscles
  - inciting cytokine mediated inflammation

Deib et AJR 2019
Yevich et al Semin Interven Radiol 2018

A WALK TO THE PAST

VP → SP → CP



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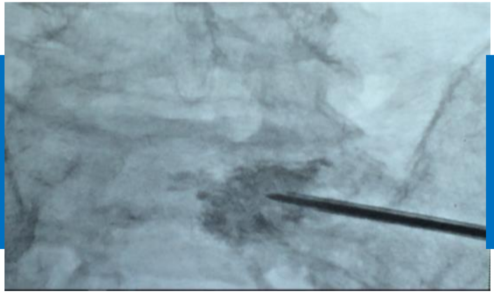

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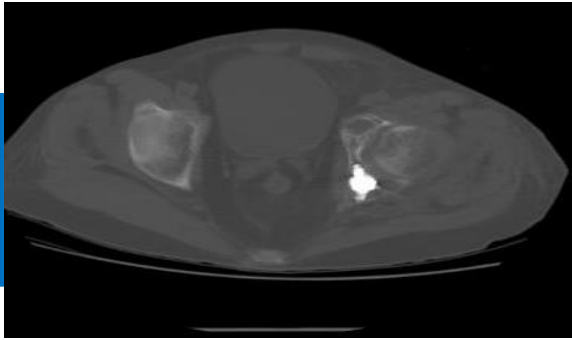
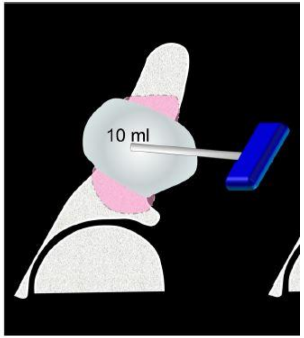


CEMENTOPLASTY

Injecting cement through a trocar, into a weakened bone, to achieve consolidation and pain management

Cementoplasty is performed to treat pain by reducing the activity of pain-sensitive periosteal nerves by means of internal trabecular stabilization



•Moser et al Cementoplasty of pelvic bone metastases: systematic assessment of lesion filling and other factors that could affect the clinical outcomes. Skeletal Radiol 2019

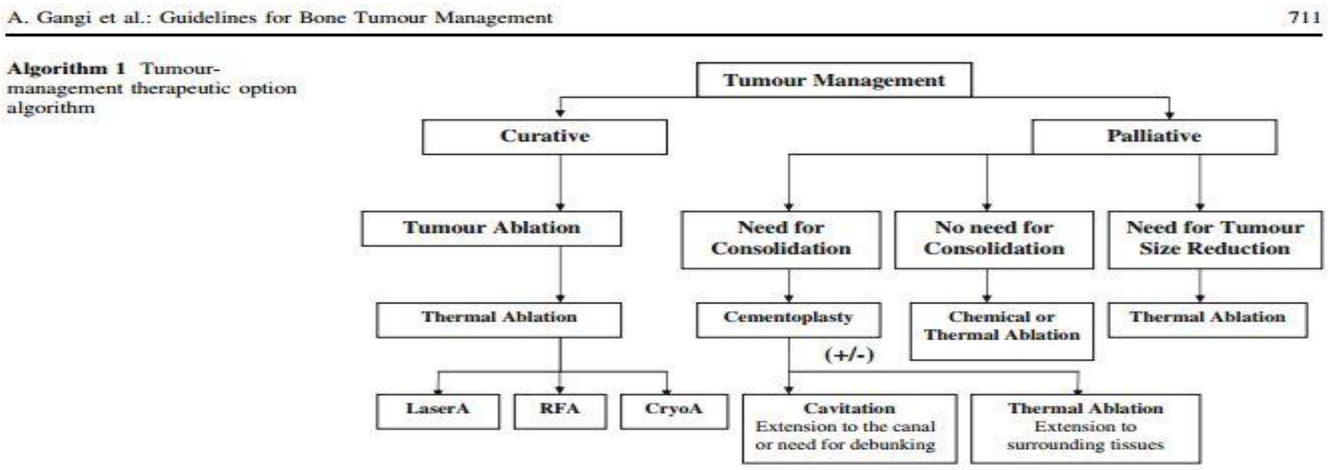
• Deib et al Percutaneous Microwave Ablation and Cementoplasty: Clinical Utility in the Treatment of Painful Extraspinal Osseous Metastatic Disease and Myeloma AJR 2019

CEMENTOPLASTY

- **INDICATIONS:**
  - Painful osteolytic metastasis
  - Myeloma lesions
  - Symptomatic osteoblastic metastases (if bone is not too dense or if fissures are present)

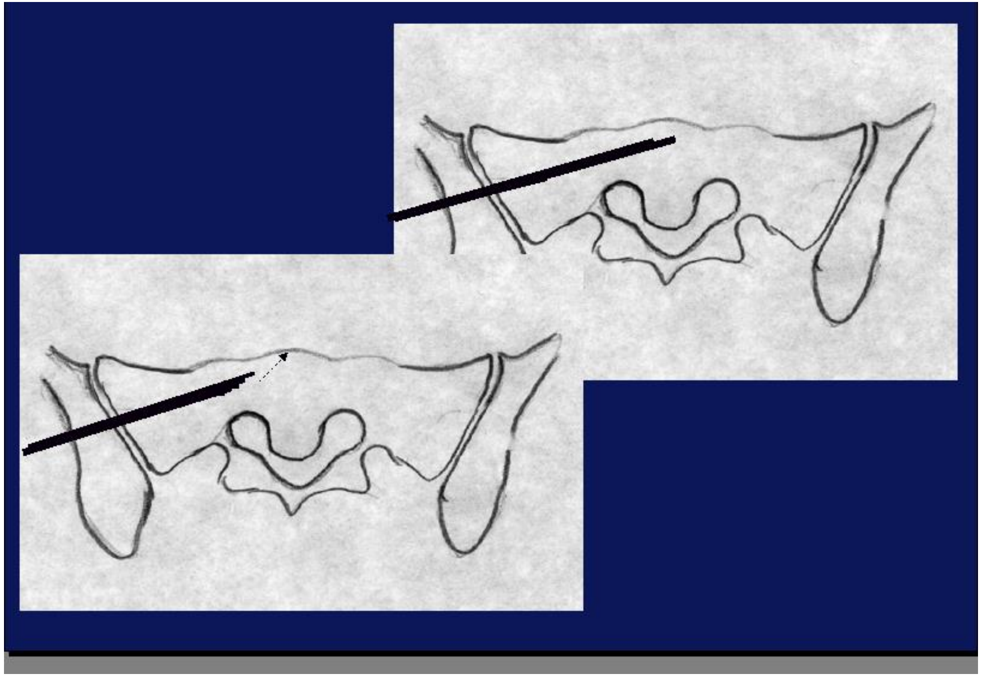
- **PRINCIPLES:**
  - Structural support
  - PMMA polymerization produces an exothermic reaction with transient peak of temperature reaching 80°C

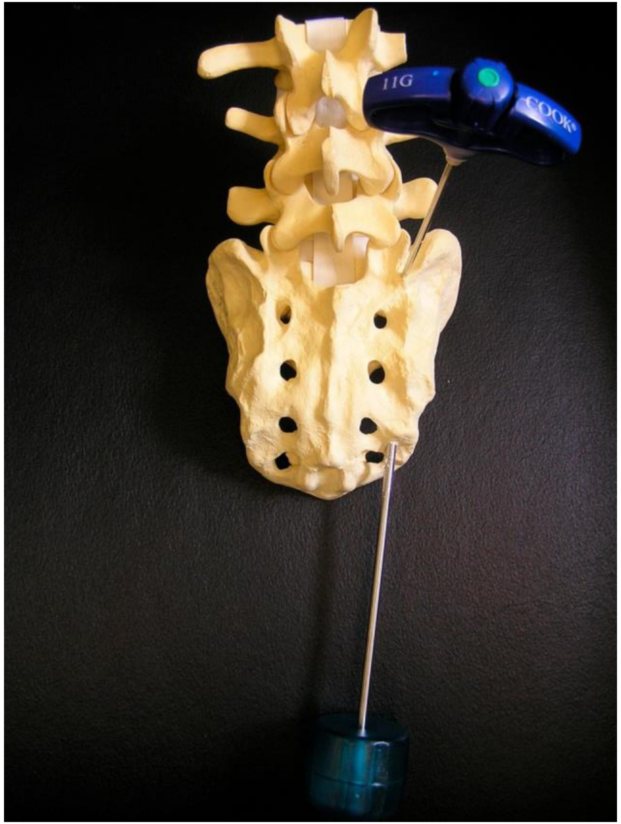
CEMENTOPLASTY



Precision of the treatment goal: curative or palliative
Fracture risk
Neurological compression

CEMENTOPLASTY





Kortman et al *Journal of NeuroInterventional Surgery* 2013

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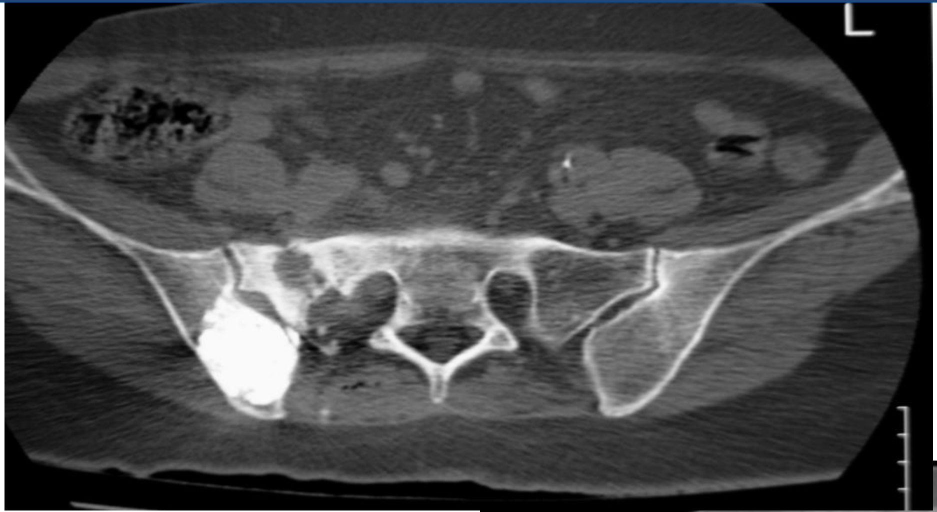
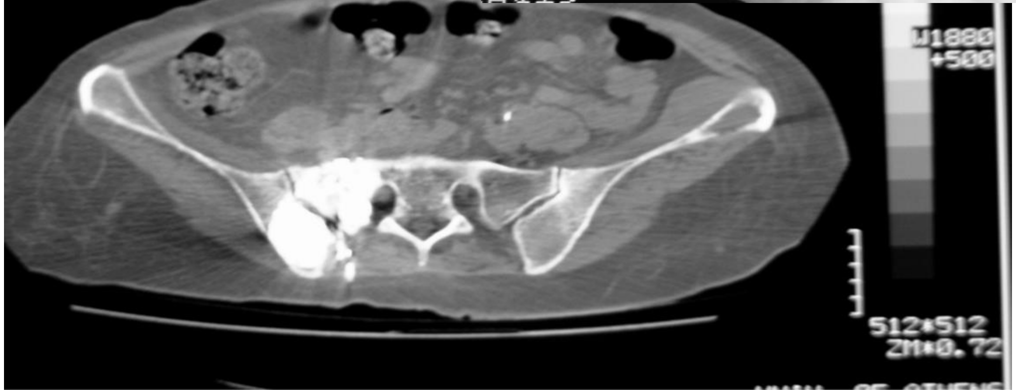
CEMENTOPLASTY





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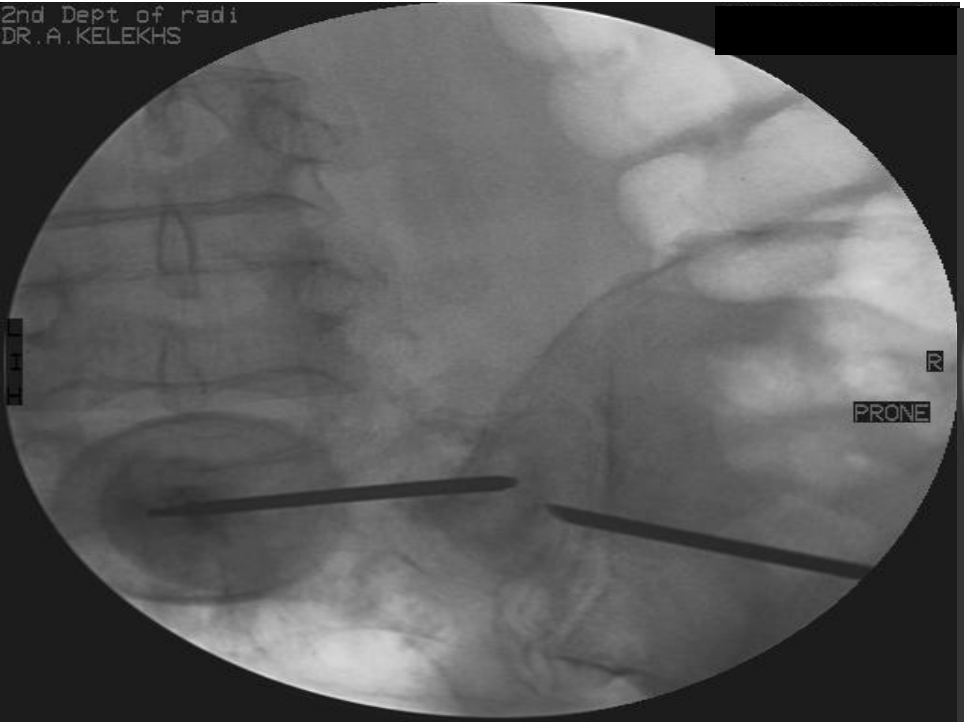
CEMENTOPLASTY



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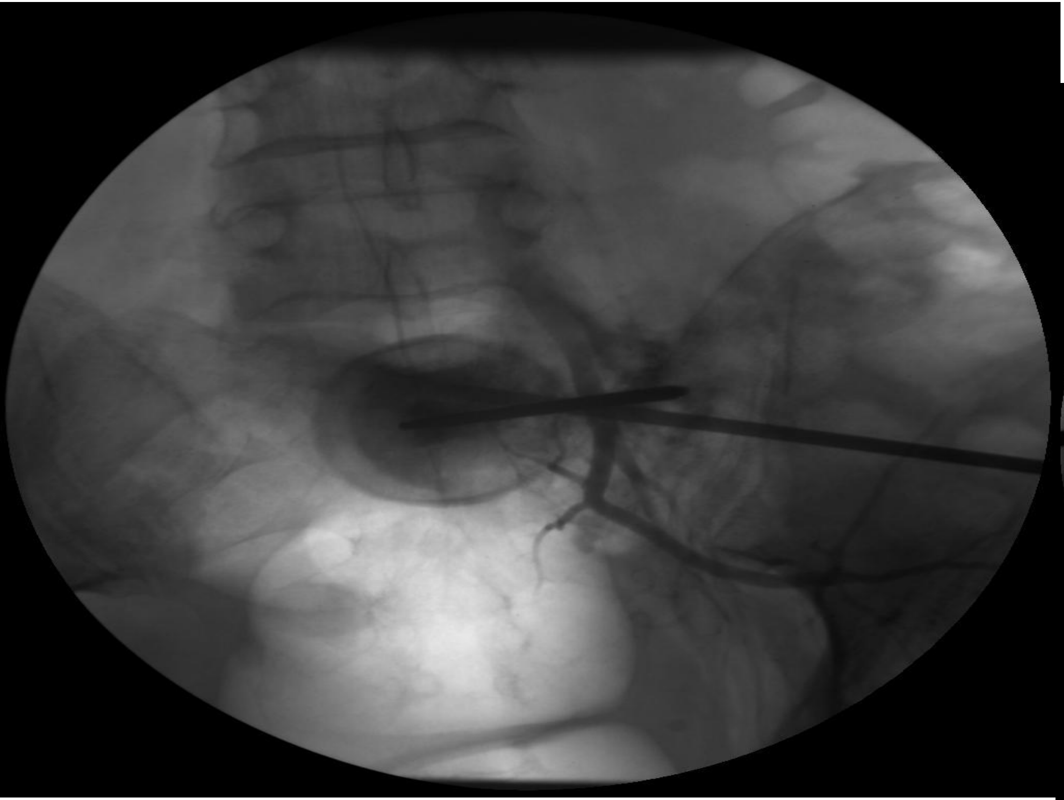

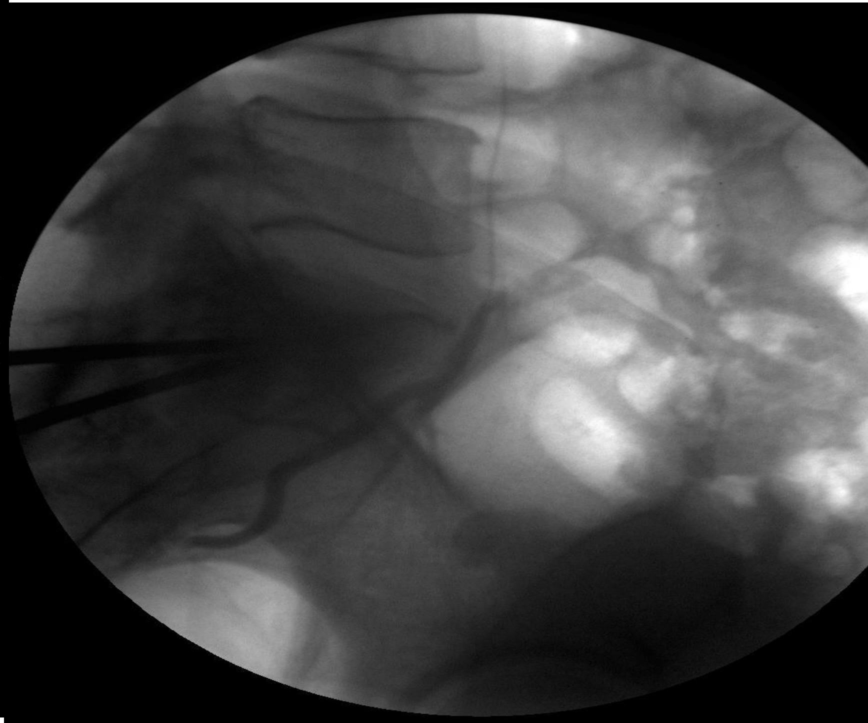

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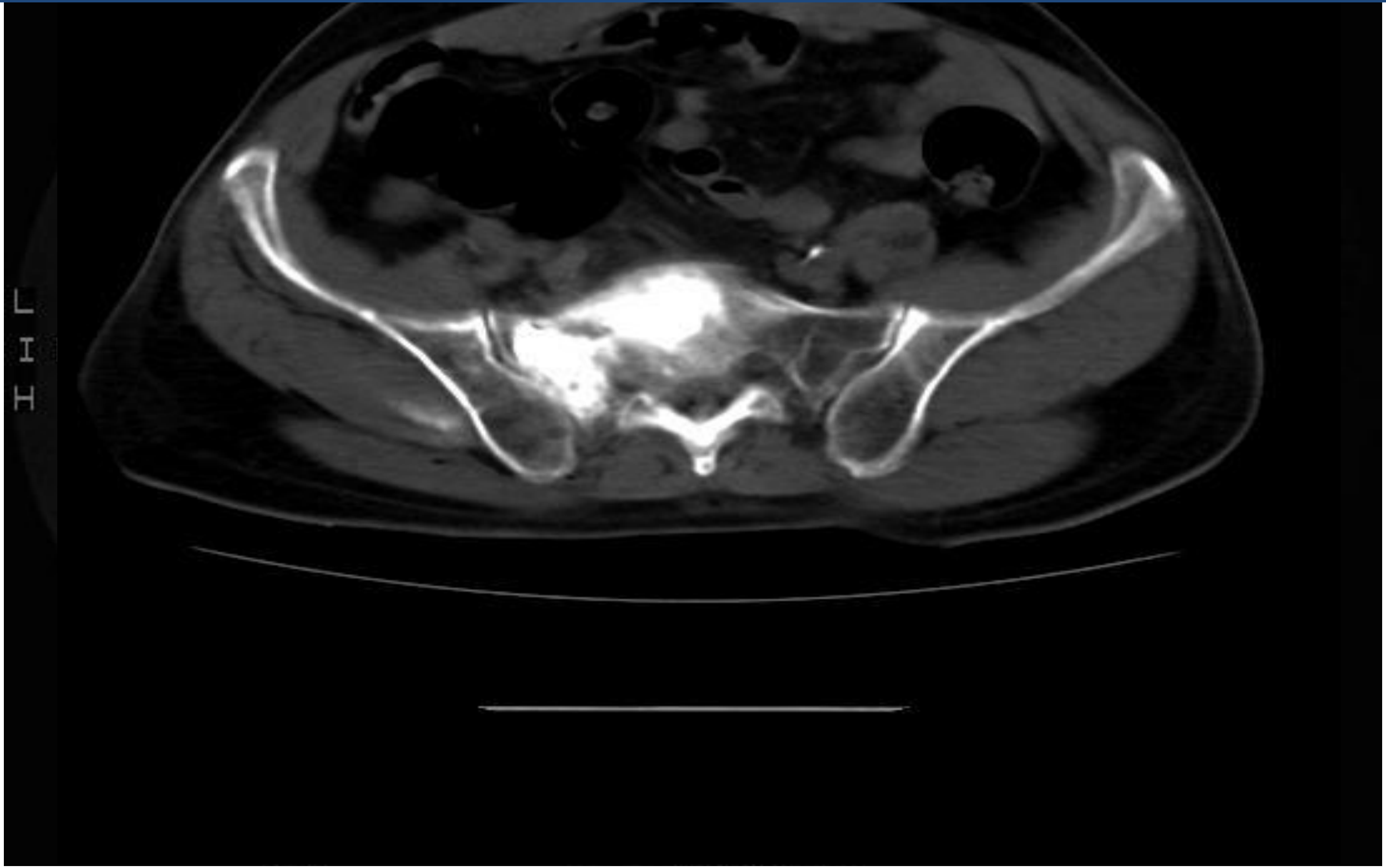

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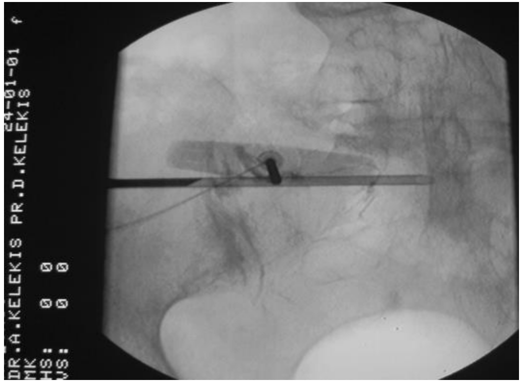
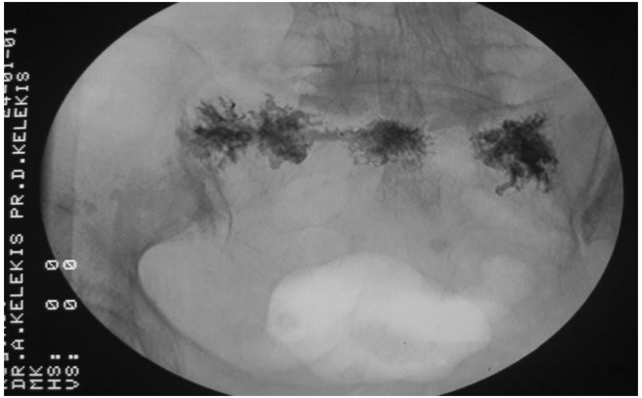
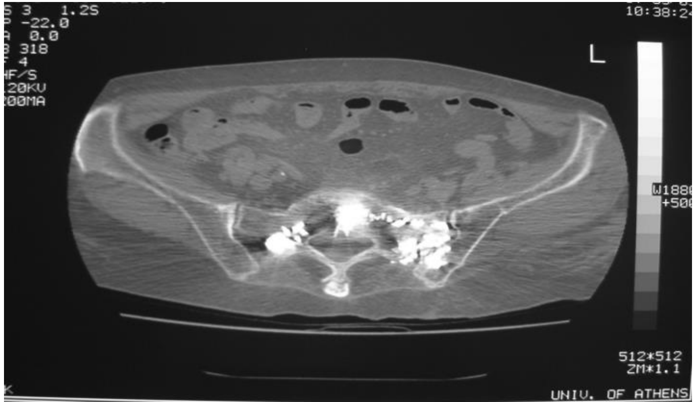






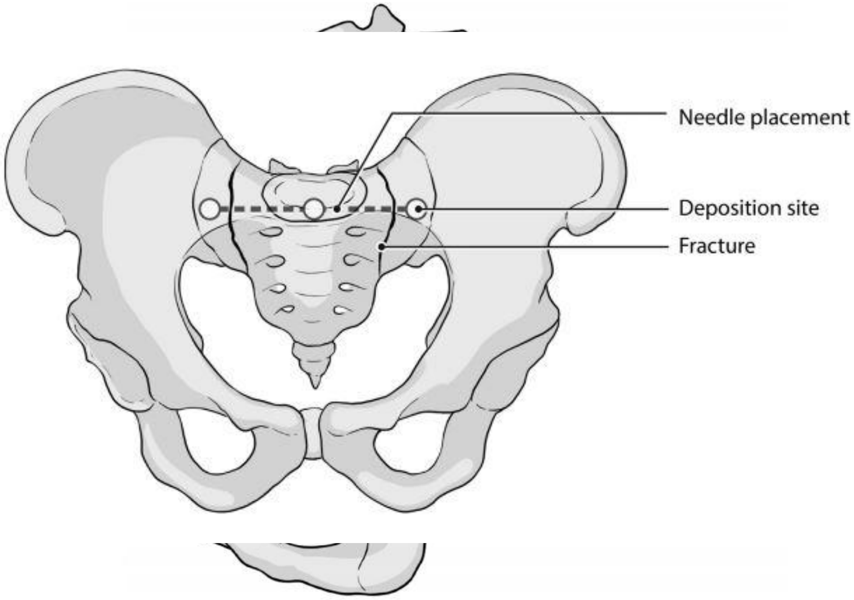
CEMENTOPLASTY

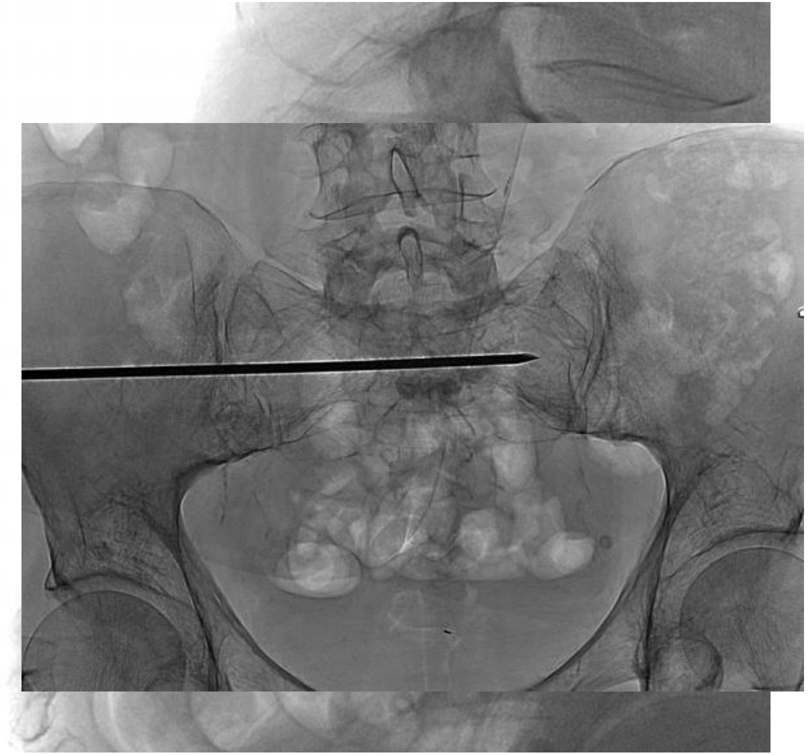
Published November 15, 2018 as 10.3174/ajnr.A5884

BRIEF/TECHNICAL REPORT
SPINE

Single-Needle Lateral Sacroplasty Technique

P.J. Nicholson, C.A. Hilditch, W. Brinjikji, A.C.O. Tsang, and R. Smith





CEMENTOPLASTY

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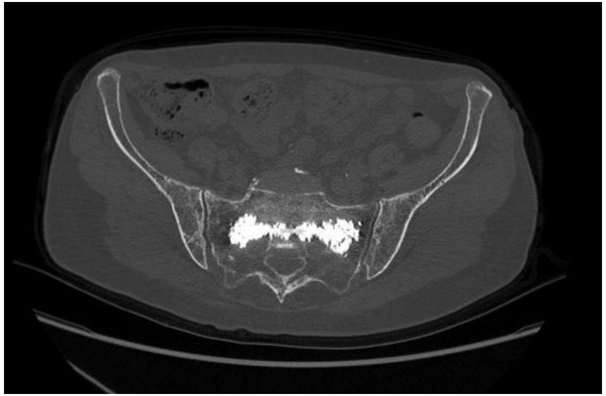

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CEMENTOPLASTY

Cazzato et al Interventional Radiologist's perspective on the management of bone metastatic disease. EJSO 41 (2015) 967e974

Table 1
Mirels' score. Adapted from Mirels' et al.[14]

	Score 1	Score 2	Score 3
Site	Upper limb	Lower limb	Peritrochanteric
Pain	Mild (<4 on a 0–10 PS)	Moderate (≥4 on a 0–10 PS)	Functionalimpairment
Lesion radiological aspect	Blastic	Mixed	Lytic
Cortical bone involvement[a]	<1/3	1/3–2/3	>2/3

Score ≤ 7: <5% risk of fracture.
Score 8: 15% risk fracture.
Score >9: High risk of fracture; stabilization should be considered.
[a] Cortical involvement could be evaluated on axial cross-sectional imaging by assessing the progressive cortical bone erosion from the medullary space to the external cortical border.

Table 1. Mirels Scoring System (13)

Mirels Score	1	2	3
Pain (visual analog scale)	≤ 4	5–7	≥ 8
Type of lesion	Blastic	Mixed	Lytic
Lesion size	< one third of cortex	One third to two thirds of cortex	> two thirds of cortex
Lesion site	Upper limb	Lower limb	Trochanteric region

CEMENTOPLASTY

Standard cementoplasty: Injection of PMMA in peripheral bones

Pain Physician 2014; 17:227-234 • ISSN 1533-3159

Cardiovasc Intervent Radiol (2008) 31:1165–1173
DOI 10.1007/s00270-008-9396-3

CLINICAL INVESTIGATION

Treatment of Extraspinal Painful Bone Metastases with Percutaneous Cementoplasty: A Prospective Study of 50 Patients

Giovanni Carlo Anselmetti · Antonio Manca · Cinzia Ortega · Giovanni Grignani · Felicino DeBernardi · Daniele Regge

50 Pts, Mirels score 11
Average follow-up 8.9 ± 5.5 mo
pathologic fracture rate 4% (2 cases)

VAS, Karnofsky scale improved
EORTC QLQ-C15-PAL improved

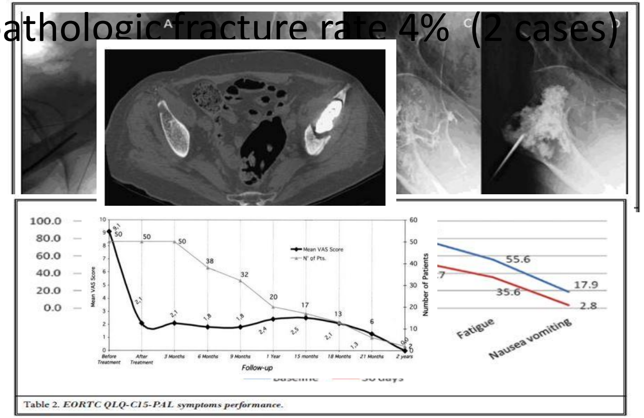

Table 2. EORTC QLQ-C15-PAL symptoms performance.

Eur Radiol (2014) 24:731–737
DOI 10.1007/s00330-013-3071-z

INTERVENTIONAL

Cementoplasty for managing painful bone metastases outside the spine

Gang Sun · Peng Jin · Xun-wei Liu · Min Li · Li Li

21 Pts, Mirels score 11
median follow-up 731 d (98–1.826 d)
1-year pathologic fracture rate was 40.6%

51 Pts, Mirels score >9
follow-up 3 mo
No pathologic fracture

Parameters	Preoperative	Postoperative 3 days	Postoperative 1 month	Postoperative 3 months
Mean ± SD	8.19±1.1	4.94±1.6	3.41±2.1	3.02±1.9
P value (versus preoperative)		<0.001	<0.001	<0.001

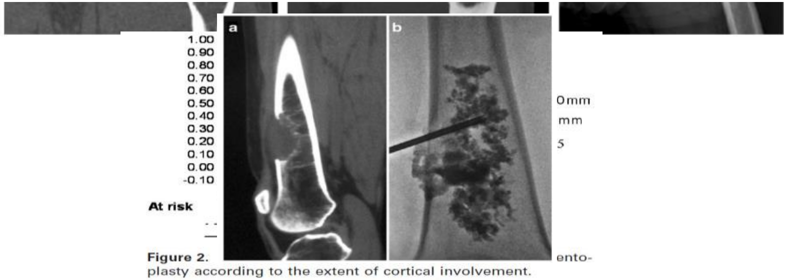

Figure 2. ... plasty according to the extent of cortical involvement.

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CEMENTOPLASTY

- Standard cementoplasty: Injection of PMMA in peripheral bones

Cardiovasc Intervent Radiol (2015) 38:1563–1572
DOI 10.1007/s00270-015-1082-7

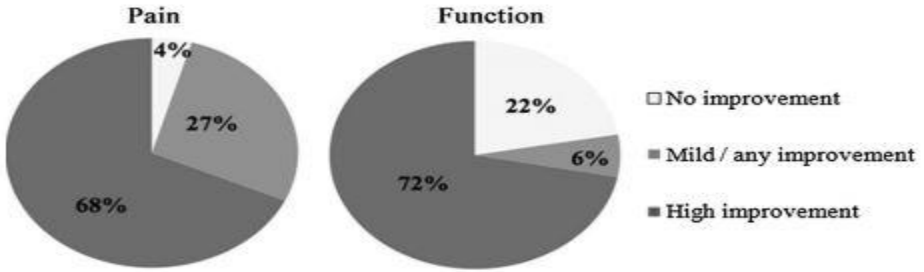
CIRSE CrossMark

CLINICAL INVESTIGATION NON-VASCULAR INTERVENTIONS

Percutaneous Long Bone Cementoplasty for Palliation of Malignant Lesions of the Limbs: A Systematic Review

Roberto Luigi Cazzato · Jean Palussière · Xavier Buy · Vincenzo Denaro · Daniele Santini · Giuseppe Tonini · Rosario Francesco Grasso · Bruno Beomonte Zobel · Dario Poretti · Vittorio Pedicini · Luca Balzarini · Ezio Lanza

	Author	Journal	Year	D	PLBC	FUP	TS (%)	PS	Pain test	MI (%)	HI (%)	Function test	MI (%)	HI (%)	SF
[26]	Toyota	CVIR	2005	Prosp.	3	15	100	–	FACES/ VAS	33	67	ADL	0	67	1
[14]	Anselmetti	CVIR	2008	Prosp.	21	9	100	–	VAS	0	100	–	–	–	2
[15]	Basile	Radiol Med.	2008	Retro.	6	6	100	–	VAS	50	50	Ambulation	0	80	0
[22]	Lane MD	Skeletal Radiol	2011	Prosp.	1	–	100	–	VAS	0	100	–	–	–	0
[23]	Masala	Support Care Cancer.	2011	Retro.	22	6	98	–	VAS	9	86	–	–	–	0
[16]	Botton E	Med Oncol	2012	Retro.	10	1	–	–	Qualitative	30	70	Ambulation	0	89	0
[18]	Deschamps	CVIR	2012	Prosp.	12	12	100	12	VAS	17	50	–	–	–	0
[17]	Deschamps	JVIR	2012	Retro.	21	24	–	0	VAS	–	–	–	–	–	7
[19]	Iannessi	Diagn Interv Imaging.	2012	Prosp.	7	8	100	–	VAS	12	88	FIM score	0	64	0
[24]	Plancarte-Sanchez	Pain Pract.	2013	Retro.	15	2	–	–	VAS	47	53	WOMMUO	12	82	0
[11]	Cazzato	Eur Radiol.	2014	Retro.	51	1	59	–	4-point Scale	42	47	4-Point Scale	37	53	6
[20]	Kim	Surg Oncol.	2014	Retro.	15	15	–	20	VAS	60	40	Ambulation	0	80	0
[25]	Sun	Eur Radiol.	2014	Retro.	12	3	100	5	VAS	–	–	–	–	–	0



Author	Patients	SF	Bone	Lesion location	Mirels' score	Delay	Surgery
Anselmetti [14]	21/50 (42.0 %)	2	Femur (2)	D (2)	N/A	30	2/2
Toyota [26]	3/17 (17.6 %)	1	Femur (1)	D (1)	N/A	2	1/1
Cazzato [11]	51/51 (100 %)	6	Femur (3)	E	9	97.5	4/6
				E-M-D			
				M			
			Humerus (3)	E-M			
				E-M			
				M-D			
Deschamps [17]	21/21 (100 %)	7	Femur (7)	E (7)	11.4	49	7/7

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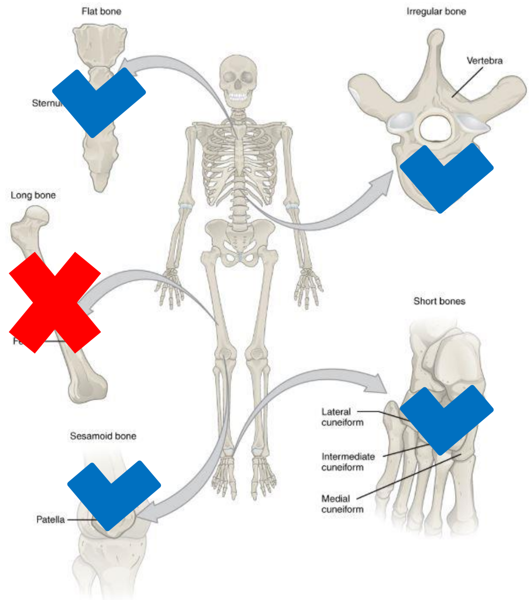
CEMENTOPLASTY

- Standard cementoplasty: Injection of PMMA in peripheral bones

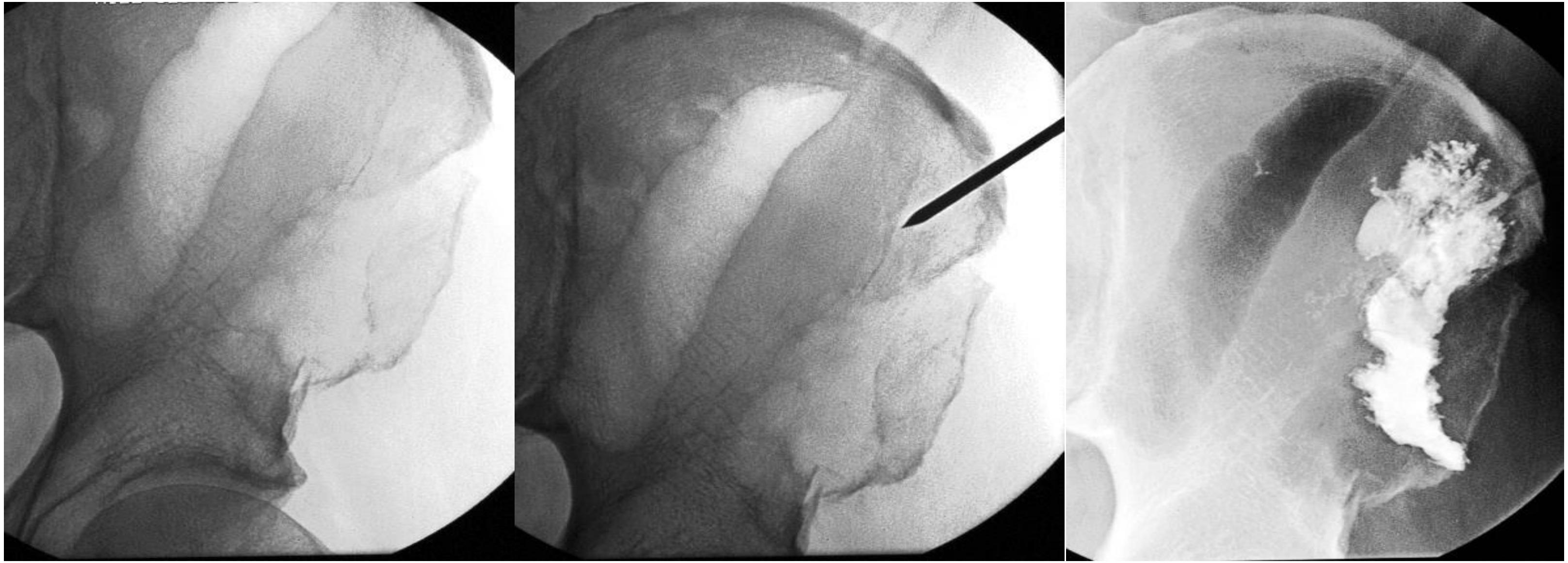
TYPE OF BONE MATTERS



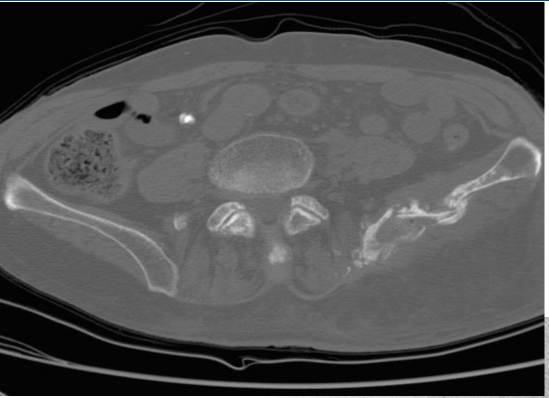
Flat bones such as acetabular roof, femoral condyles, tibial endplates, or talus can be treated effectively with percutaneous cementoplasty

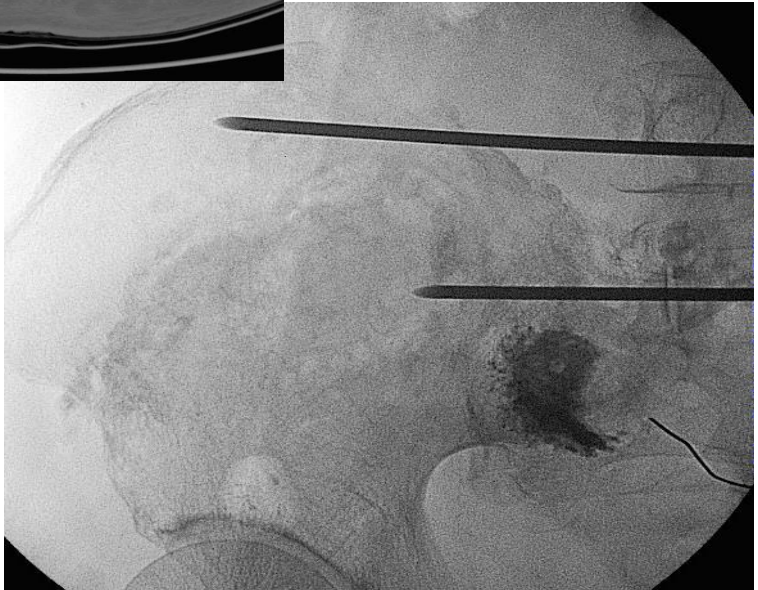
Cementoplasty of **long bone diaphysis** should be considered only in selected nonsurgical patients

CEMENTOPLASTY

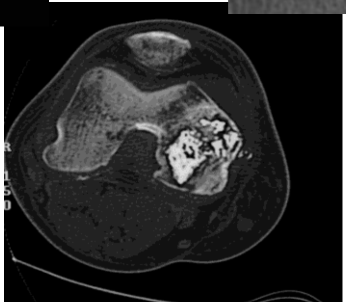


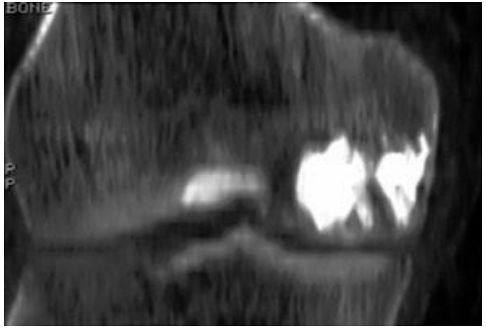
CEMENTOPLASTY





CEMENTOPLASTY

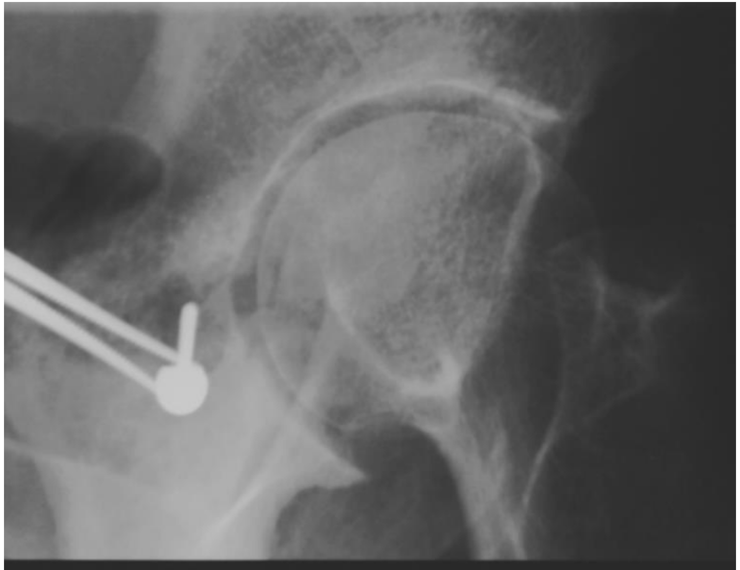


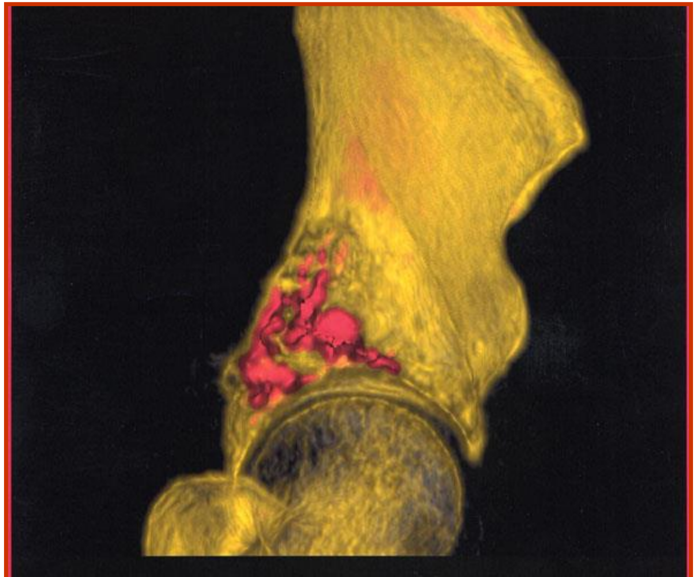


CEMENTOPLASTY

- Standard cementoplasty: Injection of PMMA in peripheral bones

LOCATION MATTERS





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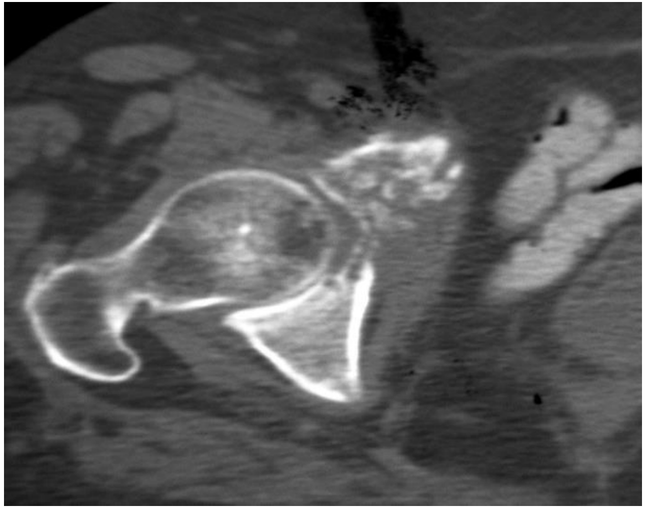
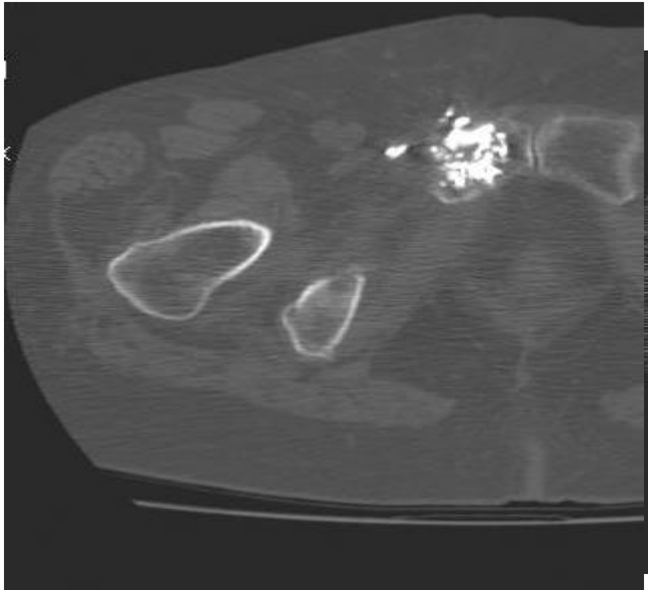
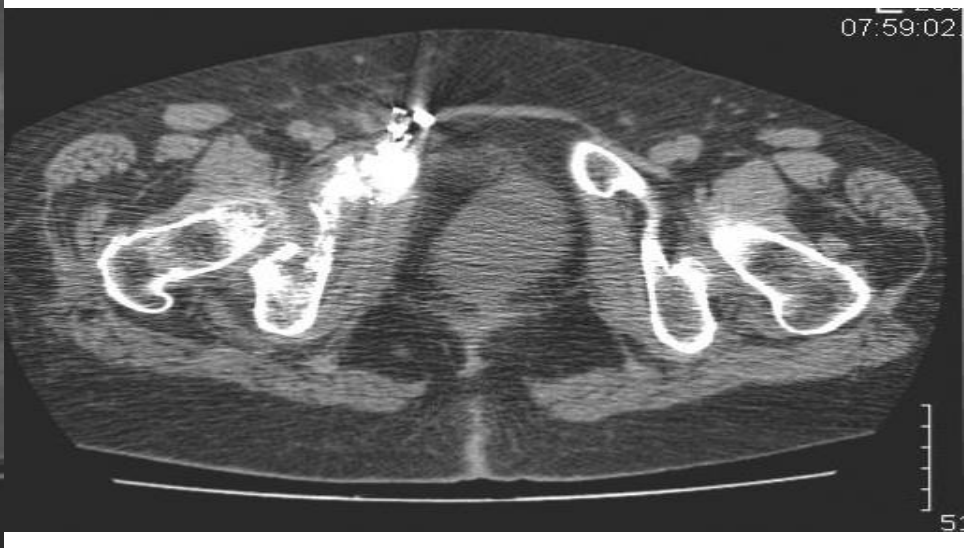


CEMENTOPLASTY





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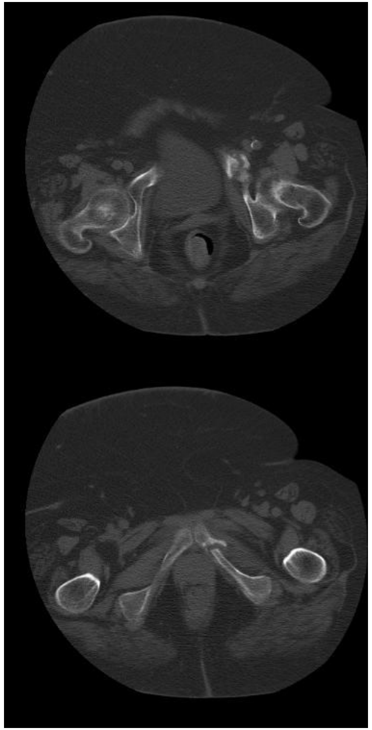
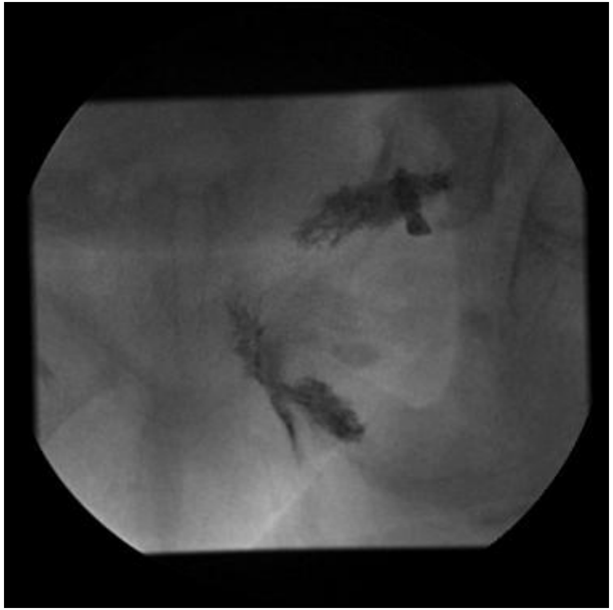
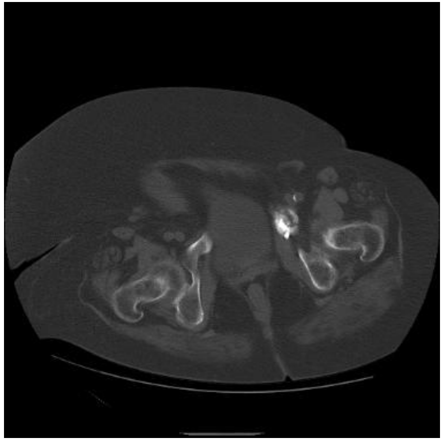
CEMENTOPLASTY

ATTIKON







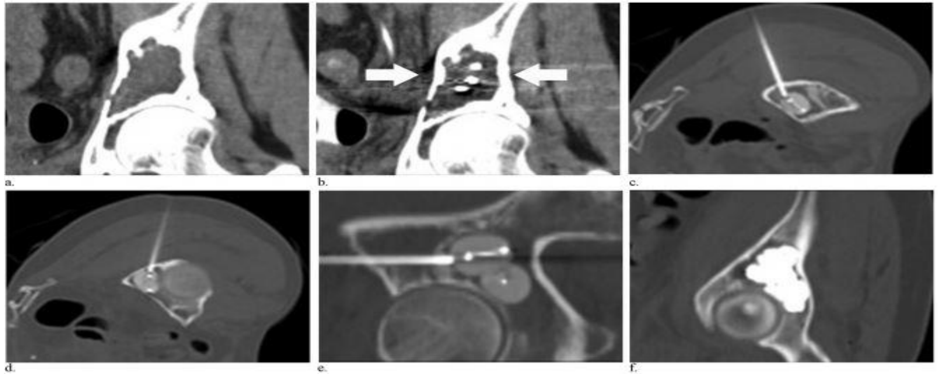
CEMENTOPLASTY

- Standard cementoplasty: Injection of PMMA in peripheral bones

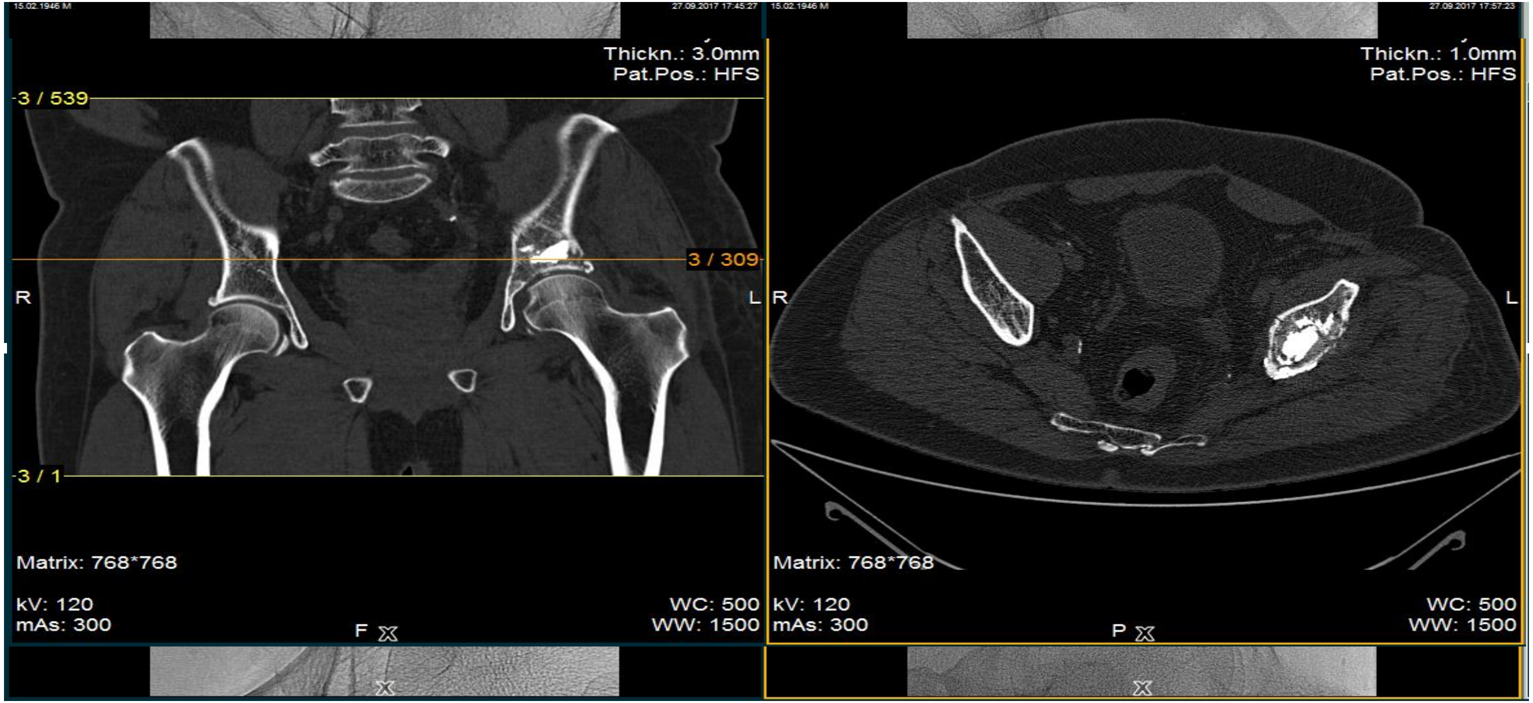
TECHNIQUE MATTERS

Balloon-Assisted Osteoplasty of Periacetabular Tumors following Percutaneous Cryoablation

A. Nicholas Kurup, MD, Jonathan M. Morris, MD, Grant D. Schmit, MD, Thomas D. Atwell, MD, John J. Schmitz, MD, Peter S. Rose, MD, and Matthew R. Callstrom, MD, PhD



CEMENTOPLASTY



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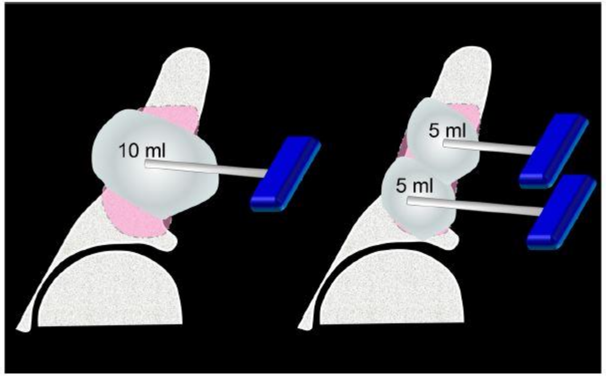
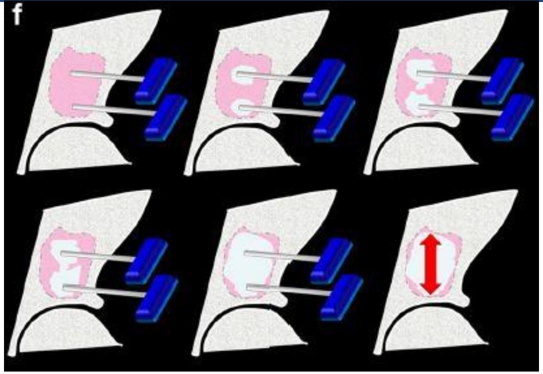
CEMENTOPLASTY





Sequential injection through several needles does not always allow the coalescence of cement streams

Avoiding leakage from the track of the first needle

Simultaneous injection produces a more compact and solid block of cement and reduces radiation exposure

Moser et al Cementoplasty of pelvic bone metastases: systematic assessment
of lesion filling and other factors that could affect the clinical outcomes. Skeletal Radiol 2019

CEMENTOPLASTY

- **Standard cementoplasty:** Injection of PMMA in peripheral bones
- **Augmented Cementoplasty:** PMMA + instrumentation for bone support/augmentation (closed fixation)

Cardiovasc Intervent Radiol (2015) 38:1563–1572
DOI 10.1007/s00270-015-1082-7

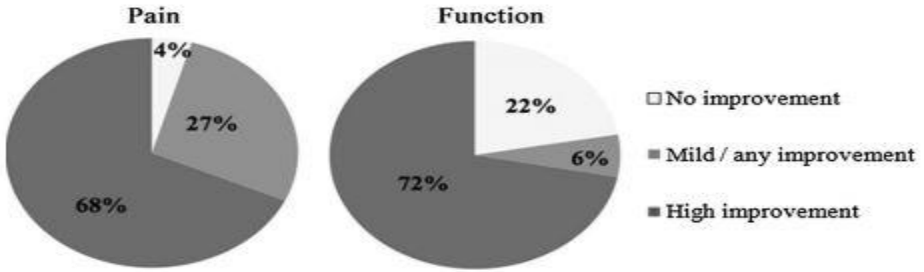
CIRSE CrossMark

CLINICAL INVESTIGATION NON-VASCULAR INTERVENTIONS

Percutaneous Long Bone Cementoplasty for Palliation of Malignant Lesions of the Limbs: A Systematic Review

Roberto Luigi Cazzato · Jean Palussière · Xavier Buy · Vincenzo Denaro · Daniele Santini · Giuseppe Tonini · Rosario Francesco Grasso · Bruno Beomonte Zobel · Dario Poretti · Vittorio Pedicini · Luca Balzarini · Ezio Lanza

	Author	Journal	Year	D	PLBC	FUP	TS (%)	PS	Pain test	MI (%)	HI (%)	Function test	MI (%)	HI (%)	SF
[26]	Toyota	CVIR	2005	Prosp.	3	15	100	–	FACES/ VAS	33	67	ADL	0	67	1
[14]	Anselmetti	CVIR	2008	Prosp.	21	9	100	–	VAS	0	100	–	–	–	2
[15]	Basile	Radiol Med.	2008	Retro.	6	6	100	–	VAS	50	50	Ambulation	0	80	0
[22]	Lane MD	Skeletal Radiol	2011	Prosp.	1	–	100	–	VAS	0	100	–	–	–	0
[23]	Masala	Support Care Cancer.	2011	Retro.	22	6	98	–	VAS	9	86	–	–	–	0
[16]	Botton E	Med Oncol	2012	Retro.	10	1	–	–	Qualitative	30	70	Ambulation	0	89	0
[18]	Deschamps	CVIR	2012	Prosp.	12	12	100	12	VAS	17	50	–	–	–	0
[17]	Deschamps	JVIR	2012	Retro.	21	24	–	0	VAS	–	–	–	–	–	7
[19]	Iannessi	Diagn Interv Imaging.	2012	Prosp.	7	8	100	–	VAS	12	88	FIM score	0	64	0
[24]	Plancarte-Sanchez	Pain Pract.	2013	Retro.	15	2	–	–	VAS	47	53	WOMMUO	12	82	0
[11]	Cazzato	Eur Radiol.	2014	Retro.	51	1	59	–	4-point Scale	42	47	4-Point Scale	37	53	6
[20]	Kim	Surg Oncol.	2014	Retro.	15	15	–	20	VAS	60	40	Ambulation	0	80	0
[25]	Sun	Eur Radiol.	2014	Retro.	12	3	100	5	VAS	–	–	–	–	–	0



Author	Patients	SF	Bone	Lesion location	Mirels' score	Delay	Surgery
Anselmetti [14]	21/50 (42.0 %)	2	Femur (2)	D (2)	N/A	30	2/2
Toyota [26]	3/17 (17.6 %)	1	Femur (1)	D (1)	N/A	2	1/1
Cazzato [11]	51/51 (100 %)	6	Femur (3)	E	9	97.5	4/6
				E-M-D			
				M			
			Humerus (3)	E-M			
				E-M			
				M-D			
Deschamps [17]	21/21 (100 %)	7	Femur (7)	E (7)	11.4	49	7/7

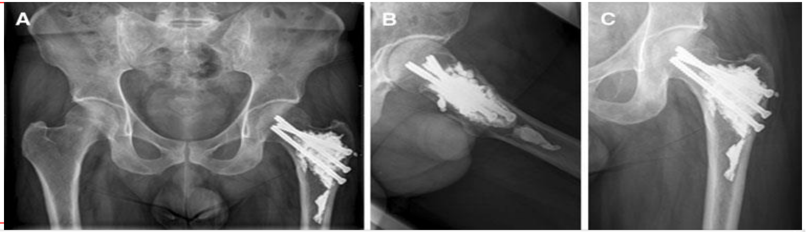
CEMENTOPLASTY

Cardiovasc Intervent Radiol (2012) 35:1428–1432
DOI 10.1007/s00270-011-0330-8

CLINICAL INVESTIGATION — NON-VASCULAR INTERVENTIONS

Percutaneous Stabilization of Impending Pathological Fracture of the Proximal Femur

Frederic Deschamps · Geoffroy Farouil · Antoine Hakime · Christophe Teriitehau · Ali Barah · Thierry de Baere



Anselmetti GC, Manca A, Chiara G et al. Painful pathologic fracture of the humerus: percutaneous osteoplasty with bone marrow nails under hybrid computed tomography and fluoroscopic guidance. J Vasc Interv Radiol. 2011 Jul;22(7):1031-1034.

Cardiovasc Intervent Radiol
DOI 10.1007/s00270-016-1333-2

CIRSE CrossMark

TECHNICAL NOTE

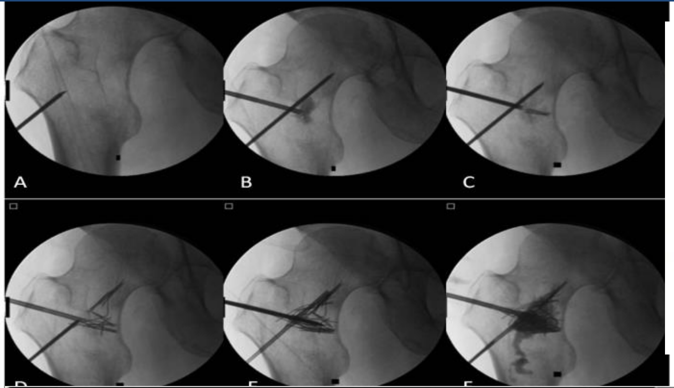
Percutaneous CT and Fluoroscopy-Guided Screw Fixation of Pathological Fractures in the Shoulder Girdle: Technical Report of 3 Cases

Julien Garnon[1] · Guillaume Koch[1] · Nitin Ramamurthy[2] · Jean Caudrelier[1] · Pramod Rao[3] · Georgia Tsoumakidou[1] · Roberto Luigi Cazzato[1] · Afshin Gangi[1]

Anselmetti GC Semin Intervent Radiol 2010
Chang et al J Vasc Interv Radiol 2005
Deschamps et al l J Vasc Interv Radiol 2012
Tsoumakidou et al CVIR 2014

Garnon et al CVIR 2015
Anselmetti et al JVIR 2011
Deschamps et al CVIR 2012
Abdel-Aal et al CVIR 2012

CEMENTOPLASTY



Cardiovasc Intervent Radiol
DOI 10.1007/s00270-015-1138-8

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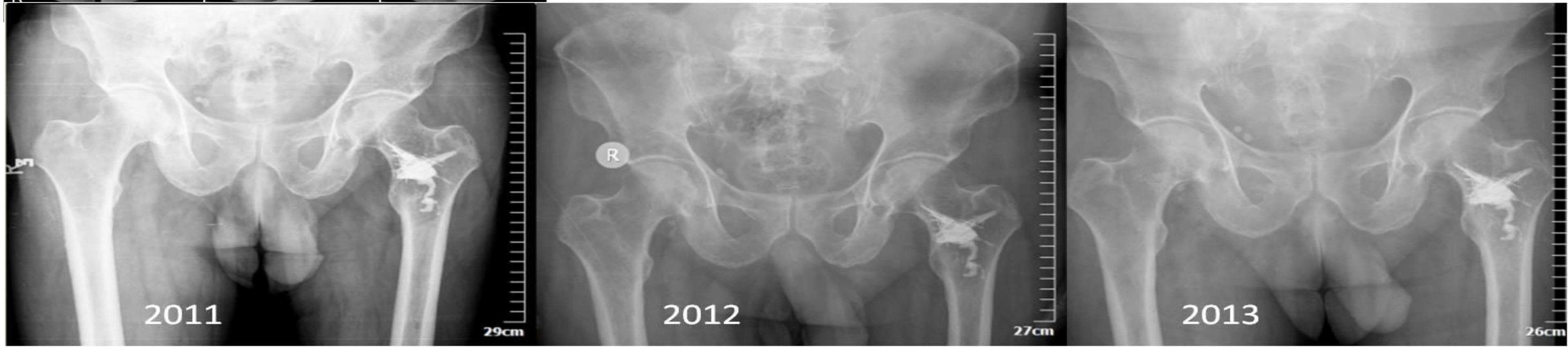
CLINICAL INVESTIGATION

Percutaneous Augmented Peripheral Osteoplasty in Long Bones of Oncologic Patients for Pain Reduction and Prevention of Impeding Pathologic Fracture: The Rebar Concept

A. Kelekis[1] · D. Filippiadis[1] · G. Anselmetti[2] · E. Brountzos[1] · A. Mavrogenis[3] · P. Papagelopoulos[3] · N. Kelekis[1] · J.-B. Martin[4]



Kelekis et al Percutaneous Augmented Peripheral Osteoplasty in Long Bones of Oncologic Patients for Pain Reduction and Prevention of Impeding Pathologic Fracture: The Rebar Concept. Cardiovasc Intervent Radiol. 2016 Jan;39(1):90-6

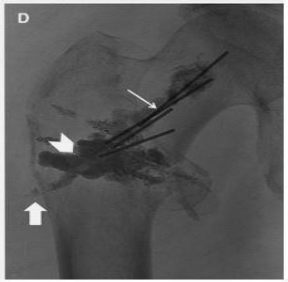
CEMENTOPLASTY

Cardiovasc Intervent Radiol (2012) 35:1211–1215
DOI 10.1007/s00270-012-0401-5

TECHNICAL NOTE

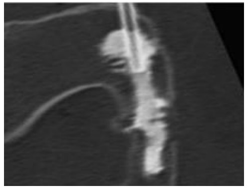
Use of Cryoablation and Osteoplasty Reinforced with Kirschner Wires in the Treatment of Femoral Metastasis

Ahmed Kamel Abdel-Aal · Edgar S. Underwood ·
Souheil Saddekni



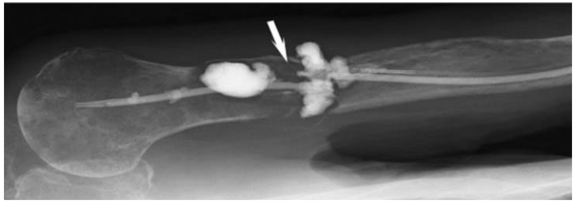
Percutaneous Repair of a Nonunion Pubic Ramus Fracture Using a Metallic Stent Scaffold and Cement Osteoplasty

John W. Kamysz, MD

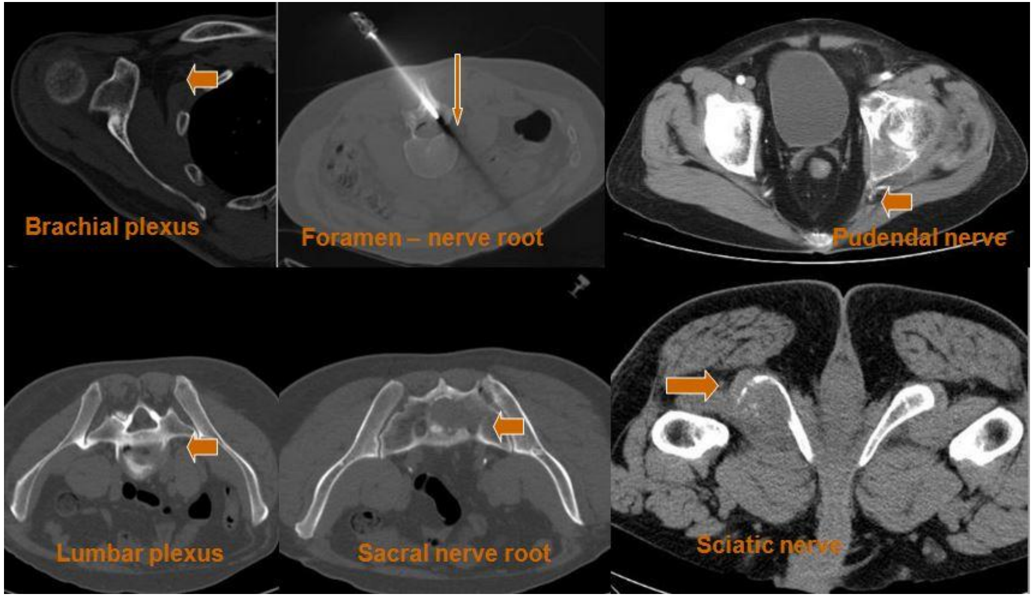


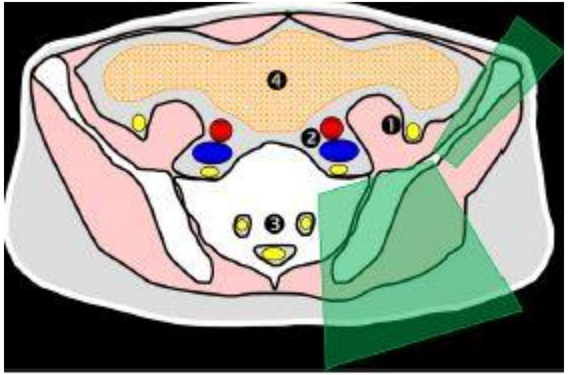
Percutaneous Osteoplasty with Use of a Cement-filled Catheter for a Pathologic Fracture of the Humerus

Nobuyuki Kawai, MD, Morio Sato, MD, Takuya Iwamoto, MD, Hirohiko Tanihata, MD, Hiroki Minamiguti, MD, and Kouhei Nakata, MD



COMPLICATIONS





Miranda et al Insights into Imaging 2018

COMPLICATIONS

- Needle access complications (direct traumatic injury to artery, nerve, or muscular tendon)
- Periosteal cement extrusion – cement leakage (Symptoms tend to result from direct compression on adjacent nerves or muscle)
- Cardiopulmonary complications (cement emboli, fat embolism, transient hypotension or bradycardia)

Yevich et al Semin Interven Radiol 2018

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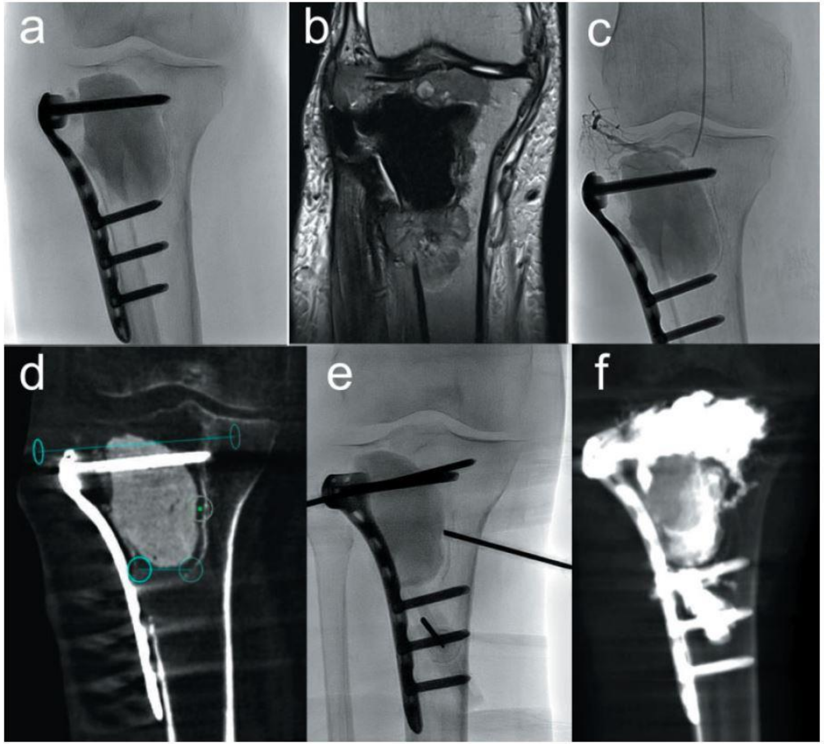
CEMENTO- COMBO

Cementoplasty + surgery
Cementoplasty + RTH
Cementoplasty + ablation
Cementoplasty + embolization
Cementoplasty + embolization + ablation

CEMENTOPLASTY+ SURGERY

- Cementoplasty can be performed after prior fixation, if surgical material becomes loose
- The aim is to preserve the osteosynthesis and thus to avoid major salvage surgery associated with high morbidity



Buy et al Semin Intervent Radiol 2018

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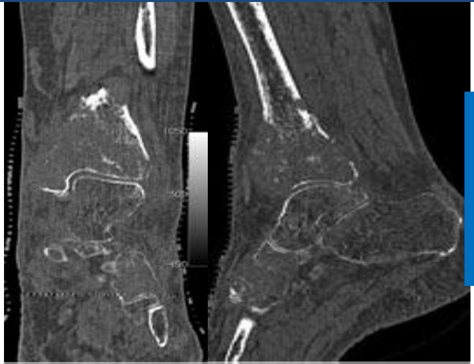
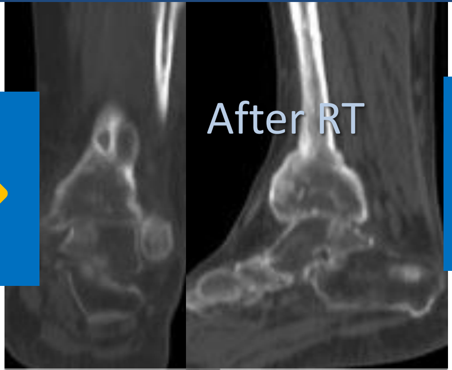
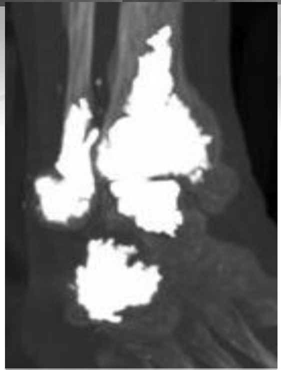
CEMENTOPLASTY +RTH







Breast metastases and high grade pain undermanaged by opiate analgesic therapy.

c/o G. Anselmetti Turin/IT

CEMENTOPLASTY+ ABLATION

Electromagnetic - Thermal	• **Radiofrequencies (RFA)** • **Microwaves (MWA)** • **Laser (LITT)**
Thermal	• **Cryoablation (CWA)**
Electromagnetic - Biological	• **Irreversible Electroporation (IRE)**
Mechanical - Thermal	• **High Intensity Focused Ultrasound (HIFU)**

- Local tumor control
- Pain relief
- Cavity creation within the tumor which promotes cement distribution

CEMENTOPLASTY+ ABLATION

Combination radiofrequency **ablation** and percutaneous osteoplasty for palliative treatment of painful extraspinal bone metastasis: a single-center experience.
Tian QH, Wu CG, Gu YF, He CJ, Li MH, Cheng YD.
J Vasc Interv Radiol. 2014 Jul;25(7):1094-100. doi: 10.1016/j.jvir.2014.03.018. Epub 2014 May 5.
PMID: 24801500
Similar articles

Retrograde Transpubic Approach for Percutaneous Radiofrequency **Ablation** and **Cementoplasty** of Acetabular Metastasis.
Bauones S, Freire V, Moser TP.
Case Rep Radiol. 2015;2015:146963. doi: 10.1155/2015/146963. Epub 2015 Sep 29.
PMID: 26491595 Free PMC Article
Similar articles

Combination acetabular radiofrequency **ablation** and **cementoplasty** using a navigational radiofrequency **ablation** device and ultrahigh viscosity cement: technical note.
Wallace AN, Huang AJ, Vaswani D, Chang RO, Jennings JW.
Skeletal Radiol. 2016 Mar;45(3):401-5. doi: 10.1007/s00256-015-2263-9. Epub 2015 Sep 26.
PMID: 26408315
Similar articles

Combined Microwave **Ablation** and **Cementoplasty** in Patients with Painful Bone Metastases at High Risk of Fracture.
Pusceddu C, Sotgia B, Fele RM, Ballicu N, Melis L.
Cardiovasc Intervent Radiol. 2016 Jan;39(1):74-80. doi: 10.1007/s00270-015-1151-y. Epub 2015 Jun 13.
PMID: 26071108
Similar articles

Balloon-assisted osteoplasty of periacetabular tumors following percutaneous cryoablation.
Kurup AN, Morris JM, Schmit GD, Atwell TD, Schmitz JJ, Rose PS, Callstrom MR.
J Vasc Interv Radiol. 2015 Apr;26(4):588-94. doi: 10.1016/j.jvir.2014.11.023.
PMID: 25805541
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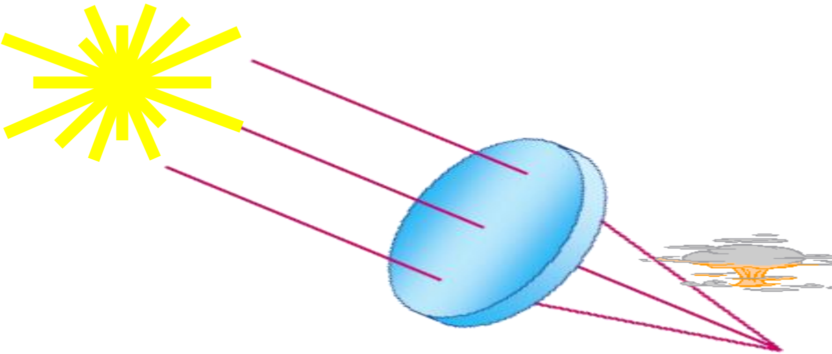

CEMENTOPLASTY+ ABLATION

CT fluoroscopy-guided percutaneous osteoplasty with or without radiofrequency ablation in the treatment of painful extraspinal and spinal bone metastases: technical outcome and complications in 29 patients

- 29 patients, 40 lesions
- Cementoplasty ± RFA

	n (%)	n of affected patients*
Localization of osteolysis		
Acetabulum	10 (25)	8
Iliac bone	4 (10)	4
Thoracic spine	6 (15)	4
Lumbar spine	5 (12.5)	5
Sacral spine	8 (20)	7
Femur	3 (7.5)	3
Tibia	1 (2.5)	1
Sternum	2 (5)	1
Glenoid	1 (2.5)	1
Total	40 (100)	
Diameter of osteolysis (cm), mean±SD (range)	4.0±1.2 (1.9–6.9)	
Osteolyses abutting risk structures		
Neuroforamen	7 (22.5)	6
Spinal canal	5 (16.1)	5
Joint	11 (35.6)	10
Other soft tissues	8 (25.8)	6
Total	31 (100)	

Burgard et al Diagn Interv Radiol 2018

CEMENTOPLASTY+ ABLATION

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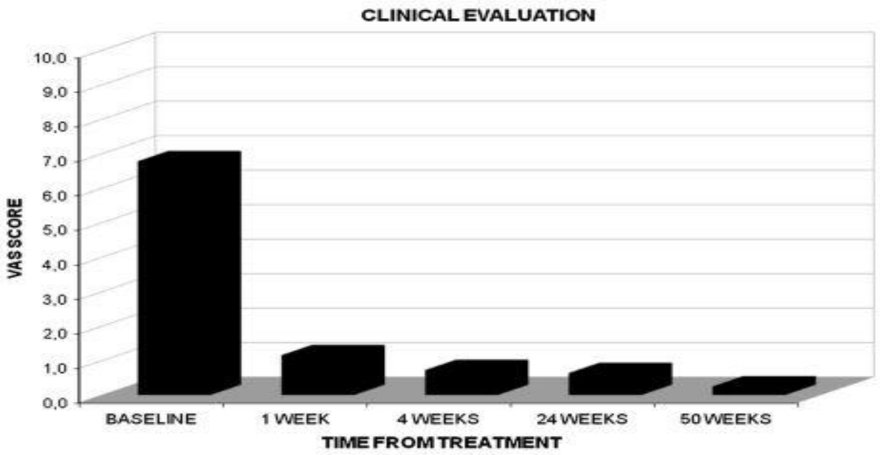
ATTIKON

Combined Microwave Ablation and Cementoplasty in Patients with Painful Bone Metastases at High Risk of Fracture

- 35 patients, 37 lesions
- MWA + cementoplasty
- 90% pain relief at 6 mo

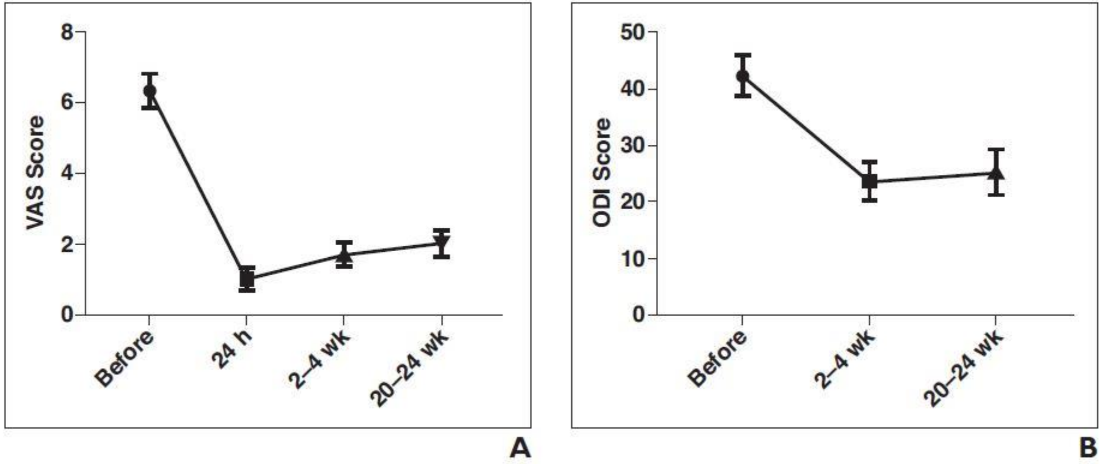


Pusceddu et Cardiovasc Intervent Radiol 2015

CEMENTOPLASTY+ ABLATION

Percutaneous Microwave Ablation and Cementoplasty: Clinical Utility in the Treatment of Painful Extraspinal Osseous Metastatic Disease and Myeloma

- 65 patients, 77 lesions
- MWA + cementoplasty
- 64.6% LTC @ 24 wk



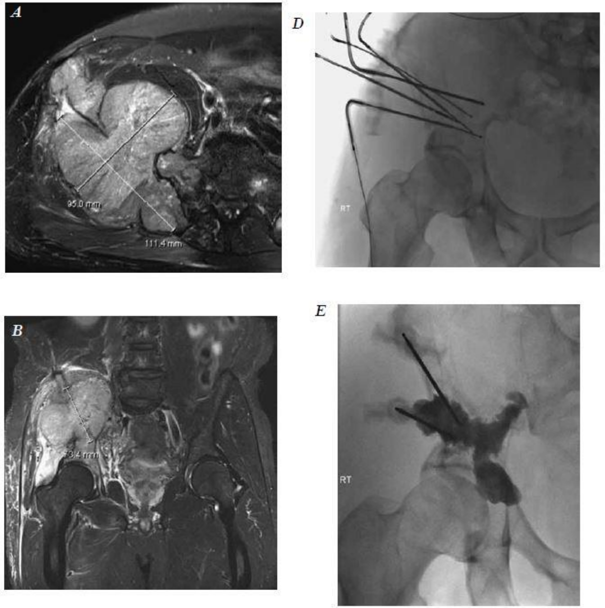
Conclusion: MWA is efficacious in alleviating pain due to osseous metastases with promise for locoregional tumor control esp in oligometastatic disease

Deib et AJR 2019

CEMENTOPLASTY+ ABLATION

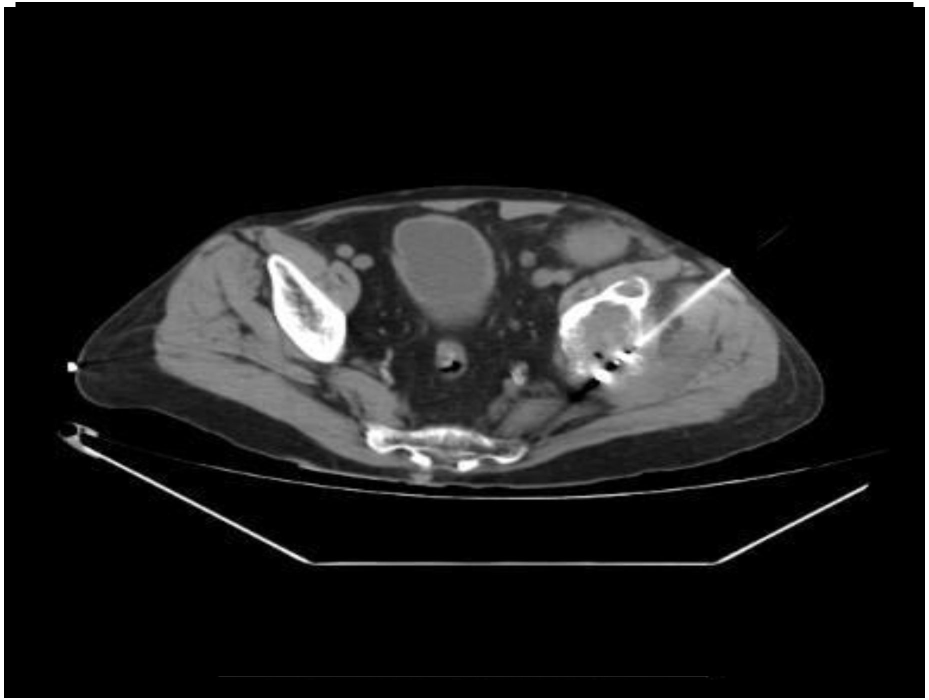
The Hopeless Case? Palliative Cryoablation and Cementoplasty Procedures for Palliation of Large Pelvic Bone Metastases

- 48 patients, >5cm diameter
- CWA + cementoplasty
- 7.9 → 1.2 NVS units



Coupal et Pain Physician 2017

CEMENTOPLASTY+ ABLATION



FUTURE DIRECTIONS

Composite cements or biocompatible calcium-phosphate cements show no benefit in oncology due to lower stability over time with less mechanical resistance

Several studies report research projects using loaded cements as therapeutic vectors (Methotrexate, cisplatin, zoledronate)

PMMA with radionuclide to reinforce focal antitumoral effect

FUTURE DIRECTIONS

BONE CEMENT in MALIGNANCY
Drugs eluting Bone Cement

National and Kapodistrian University of Athens

Polymethylmethacrylate-antiblastic drug compounds: an in vitro study assessing the cytotoxic effect in cancer cell lines--a new method for local chemotherapy of bone metastasis.
Greco F et al. Orthopedics. 1992 Feb;15(2):189-94

THE JOURNAL OF BONE & JOINT SURGERY

Acrylic cement added with antiblastics in the treatment of bone metastases
ULTRASTRUCTURAL AND IN VITRO ANALYSIS
M. A. Rosa, G. Maccauro, A. Sgambato, R. Ardito, G. Falcone, V. De Santis, F. Muratori
From the Catholic University, Rome, Italy

THE JOURNAL OF BONE & JOINT SURGERY

Cytotoxic effect of drugs eluted from polymethylmethacrylate on stromal giant-cell tumour cells
AN *IN VITRO* STUDY

Bone Cement with radioisotopes

Pain Physician 2009; 12:887-891 • ISSN 1533-3159

Focused Review

Polymethylmethacrylate and Radioisotopes in Vertebral Augmentation: An Underlying Principles

Ariel E. Hirsch, MD, Barry S. Rosenstein, PhD, David C... Christopher B. Martel, CHP, and Joshua A. Hirsch, MD

IOP Publishing

Evaluation of a radiation transport modeling method for radioactive bone cement

Bone Cement with magnetic particles
(external magnetic field induced hyperthermia)

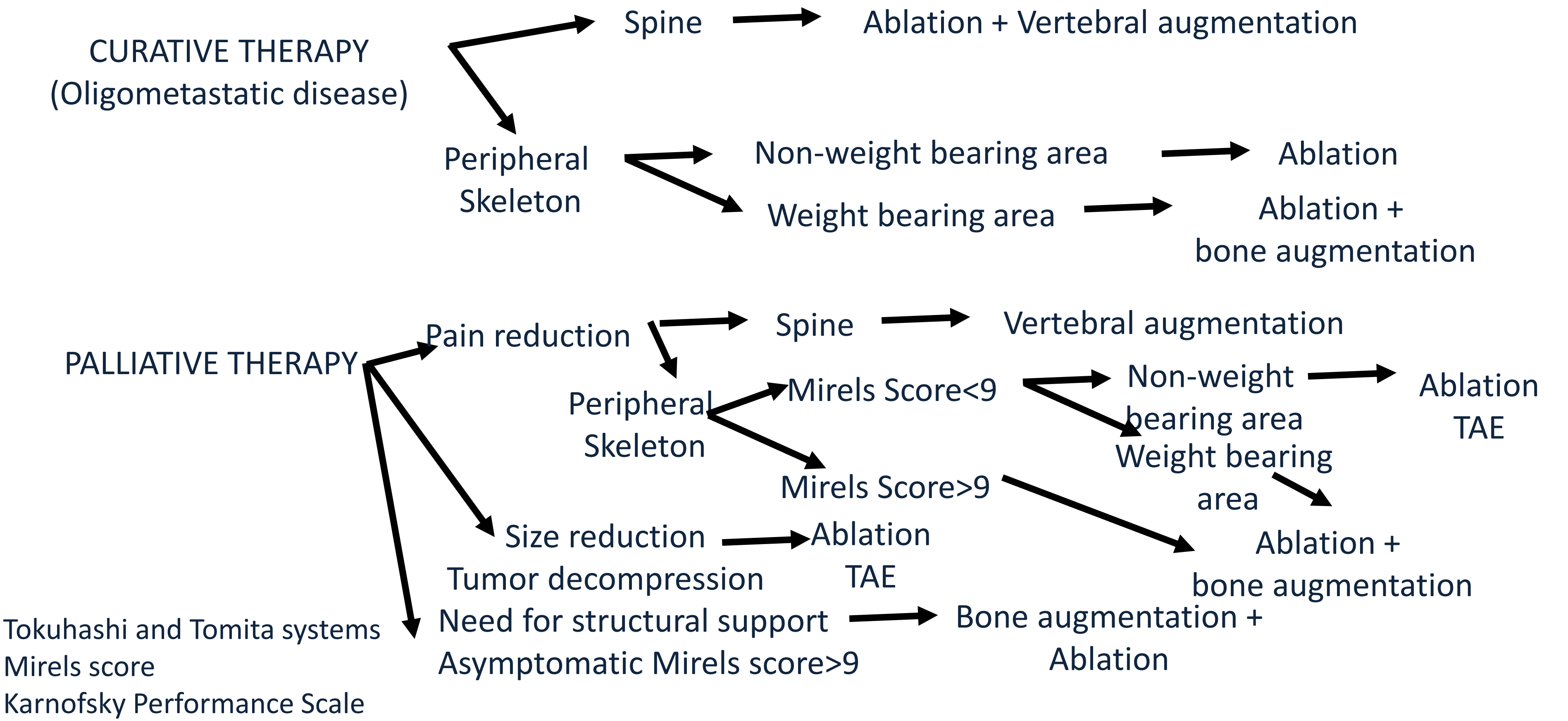
Biphasic materials for bone grafting and hyperthermia treatment of cancer

D. Arcos, R. P. del Real, M. Vallet-Regí
Dpto. Química Inorgánica y Bioinorgánica, Fac. de Farmacia, UCM, Pza. Ramón y Cajal, s/n. 28040 Madrid, Spain

Contents lists available at ScienceDirect
Acta Biomaterialia
journal homepage: www.elsevier.com/locate/actabiomat

PMMA-based bone cements containing magnetite particles for the hyperthermia of cancer
M. Kawashita, K. Kawamura, Z. Li

THERAPEUTIC ALGORITHM



TAKE HOME MESSAGES……

- In advanced cancer, bone is a common site of metastases characterized by substantial skeletal morbidity

- Pain reduction → limits beds rest

- Cementoplasty is quickly effective for pain relief with long term efficacy on pain and improvement of functional disability and quality of life

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