
XXXIII CONGRESSO NAZIONALE AIRO
AIRO2023
BOLOGNA,
27-29 OTTOBRE 2023
PALAZZO DEI CONGRESSI
Radioterapia Oncologica: l'evoluzione al servizio dei pazienti
Radioterapia stereotassica nelle metastasi vertebrali: sempre e comunque? Perché sì
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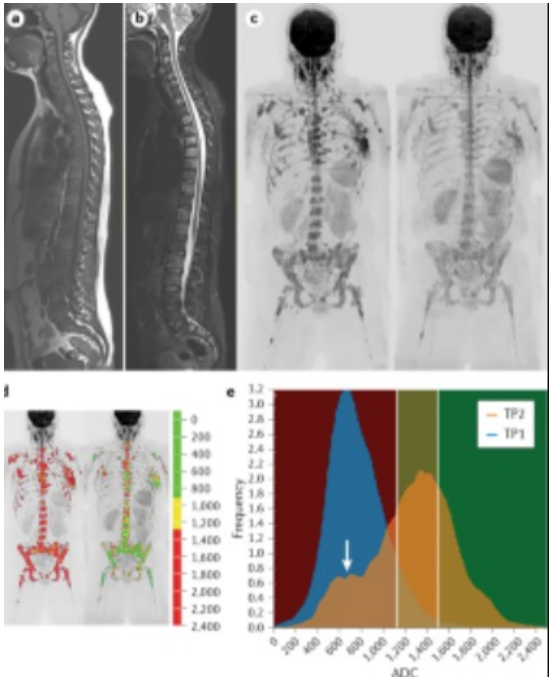
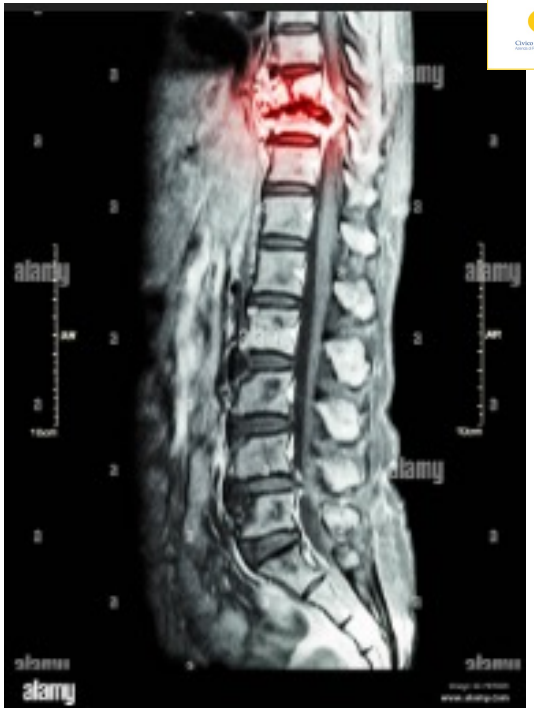
Radioterapia e Oncologia clinica

No disclosures for this presentation



- considerable morbidity
- pain
- fractures
- impaired quality of life

Only one-third of patients who respond to conventional radiotherapy achieve a complete pain response, and 40% do not experience any substantial improvement in symptoms. Strikingly, 50% of patients who initially respond to treatment experience symptom relapse within a year.

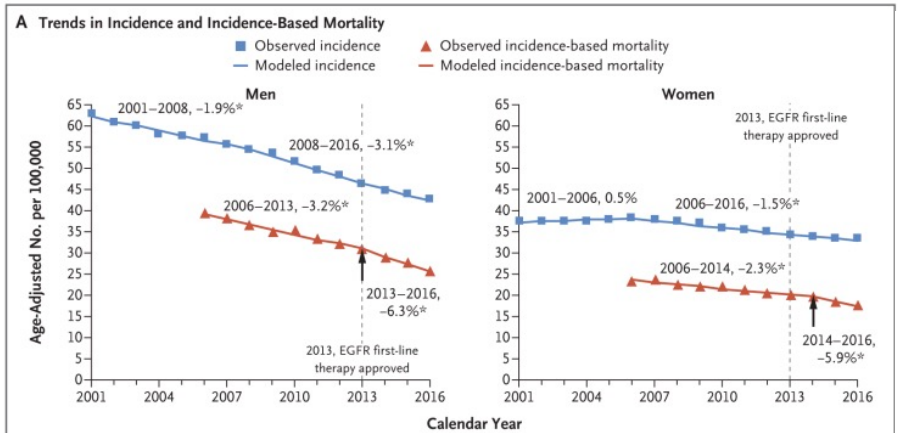


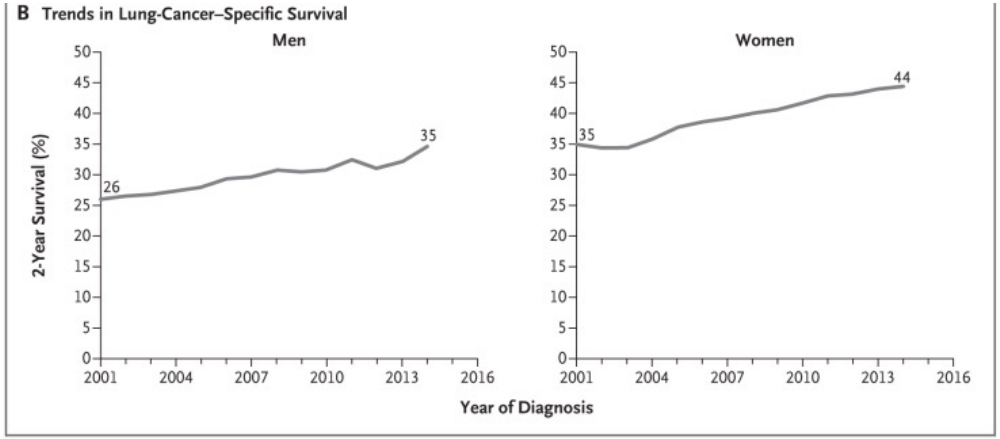
Kotecha et al, Neuro-Oncology Practice 2020

N Engl J Med. 2020 Aug 13;383(7):640-649. doi: 10.1056/NEJMoa1916623.

The Effect of Advances in Lung-Cancer Treatment on Population Mortality

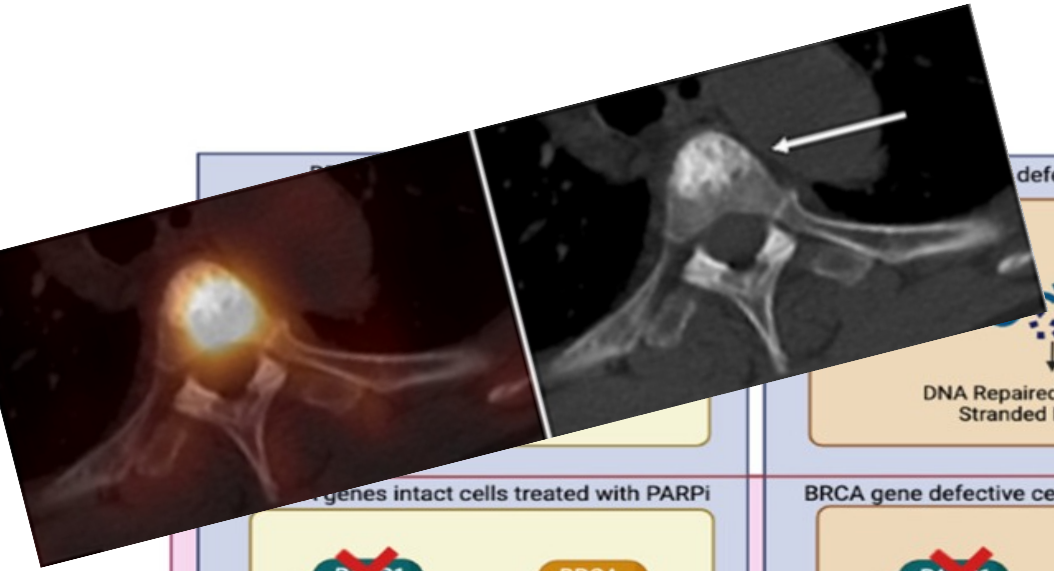
Nadia Howlader [1], Gonçalo Forjaz [1], Meghan J Mooradian [1], Rafael Meza [1], Chung Yin Kong [1], Kathleen A Cronin [1], Angela B Mariotto [1], Douglas R Lowy [1], Eric J Feuer [1]

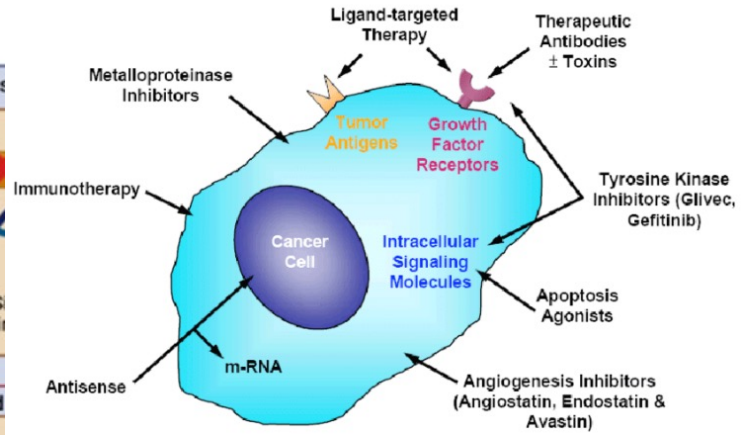




AIRO2023

Radioterapia Oncologica:
l'evoluzione al servizio dei pazienti





Participants were randomly assigned (1:1) to receive single-fraction SBRT (24 Gy) or 3DCRT (30 Gy in 10 fractions). The primary endpoint was pain relief of >2 points on the visual analog scale (VAS) measured within the irradiated region at 3 months following radiotherapy completion.

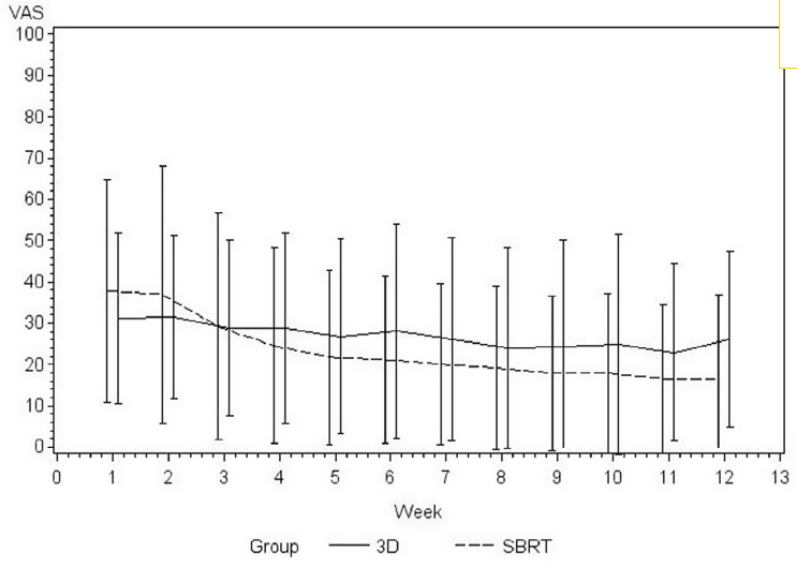


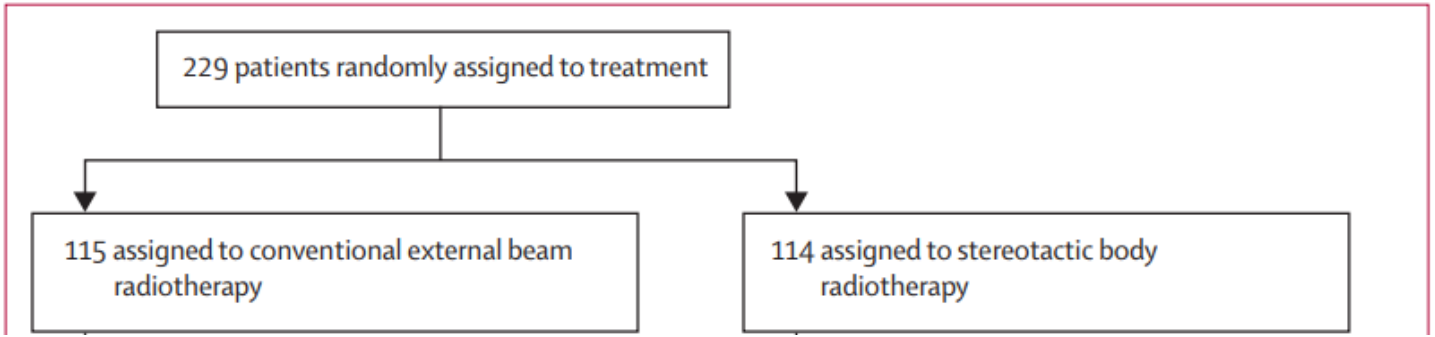
Fig. 4. VAS-value in both groups during 12 weeks after end of the radiotherapy.

Despite no significant differences for VAS at 3 months between groups (p = 0.13), pain values decreased faster within this time period in the SBRT arm (p = 0.01). At 6 months following RT, significantly lower VAS values were reported in the SBRT group (p = 0.002).

Radiotherapy and Oncology 128 (2018) 274–282

Stereotactic body radiotherapy versus conventional external beam radiotherapy in patients with painful spinal metastases: an open-label, multicentre, randomised, controlled, phase 2/3 trial

Lancet Oncol 2021; 22: 1023-33



Interpretation Stereotactic body radiotherapy at a dose of 24 Gy in two daily fractions was superior to conventional external beam radiotherapy at a dose of 20 Gy in five daily fractions in improving the complete response rate for pain. These results suggest that use of conformal, image-guided, stereotactically dose-escalated radiotherapy is appropriate in the palliative setting for symptom control for selected patients with painful spinal metastases, and an increased awareness of the need for specialised and multidisciplinary involvement in the delivery of end-of-life care is needed.

At 3 months, 40 (35%) of 114 patients in the stereotactic body radiotherapy group, and 16 (14%) of 115 patients in the conventional external beam radiotherapy group had a complete response for pain (risk ratio 1·33, 95% CI 1·14–1·55; p=0·0002). The most common grade 3–4 adverse event was grade 3 pain (five [4%] of 115 patients in the conventional external beam radiotherapy group vs five (5%) of 110 patients in the stereotactic body radiotherapy group).

	Conventional external beam radiotherapy group (n=115)	Stereotactic body radiotherapy group (n=114)	p value
1-month assessment			
Complete response	20 (17%)	30 (26%)	0·10*
Partial response	33 (29%)	34 (30%)	..
Stable pain	38 (33%)	26 (23%)	..
Progressive pain	14 (12%)	9 (8%)	..
Indeterminant	10 (9%)	15 (13%)	..
Mean daily OME consumption, mg	44 (122)	27 (95)	0·26
3-month assessment			
Complete response	16 (14%)	40 (35%)	0·0002*
Partial response	29 (25%)	20 (18%)	..
Stable pain	34 (30%)	27 (24%)	..
Progressive pain	14 (12%)	7 (6%)	..
Indeterminant	22 (19%)	20 (18%)	..
Mean daily OME consumption, mg	43 (106)	37 (97)	0·70
Mean change in SINS from baseline	−0·49 (1·61)	−0·94 (1·69)	0·034
6-month assessment			
Complete response	18 (16%)	37 (32%)	0·0036*
Partial response	18 (16%)	10 (9%)	..
Stable pain	32 (28%)	26 (23%)	..
Progressive pain	8 (7%)	5 (4%)	..
Indeterminant	39 (34%)	36 (32%)	..
Mean daily OME consumption, mg	36 (126)	36 (84)	1·00
Mean change in SINS from baseline	−0·74 (1·99)	−0·73 (1·86)	0·88

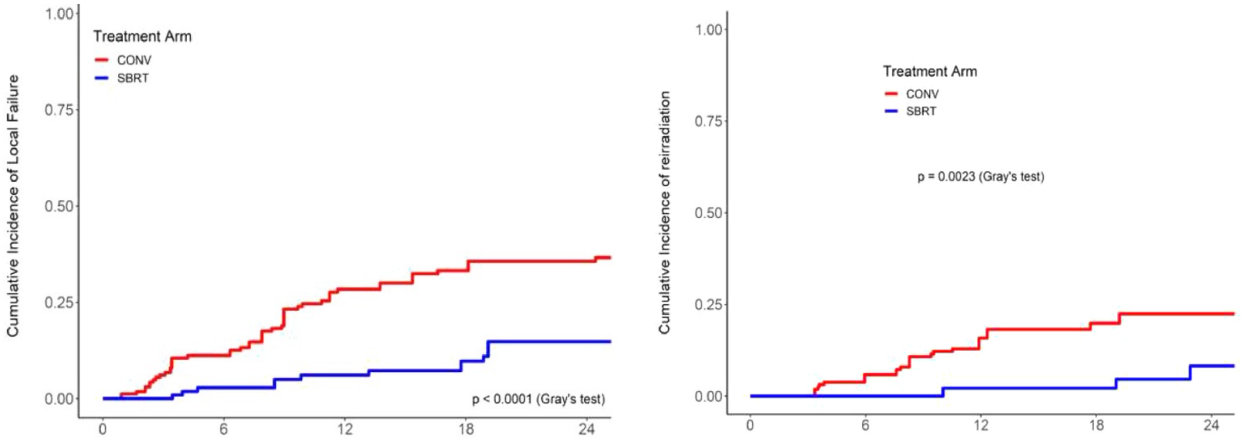
CLINICAL INVESTIGATION | VOLUME 114, ISSUE 2, P293-300, OCTOBER 01, 2022

ASTRO

Mature Local Control and Reirradiation Rates Comparing Spine Stereotactic Body Radiation Therapy With Conventional Palliative External Beam Radiation Therapy

K. Liang Zeng, MD • Sten Myrehaug, MD • Hany Soliman, MD • ... Pejman Jabehdar Maralani, MD • Wendy R. Parulekar, MD • Arjun Sahgal, MD • Show all authors

Risk of local failure and re-irradiation is lower with SBRT compared with cEBRT for spinal metastases.



Although the iatrogenic vertebral compression fracture rates were within expectations, grade 3 vertebral compression fractures were isolated to the SBRT cohort.

Clinical Trial > Int J Radiat Oncol Biol Phys. 2023 Mar 1;115(3):686-695.
doi: 10.1016/j.ijrobp.2022.09.076. Epub 2022 Oct 26.

Dose-Escalated 2-Fraction Spine Stereotactic Body Radiation Therapy: 28 Gy Versus 24 Gy in 2 Daily Fractions

K Liang Zeng [1], Ahmed Abugarib [2], Hany Soliman [1], Sten Myrehaug [1], Zain A Husain [1], Jay Detsky [1], Mark Ruschin [1], Aliaksandr Karotki [1], Eshetu G Atenafu [3], Jeremie Larouche [4], Mikki Campbell [1], Pejman Maralani [5], Arjun Sahgal [1], Chia-Lin Tseng [6]

- 301 segments in 159 patients received 28 Gy and 646 segments in 323 patients received 24 Gy in 2 fractions.
- Median follow-up 23.5 months, and median overall survival was 49.1 months
- In the 28 Gy cohort, the 6-, 12-, and 24-month cumulative incidences of LF were 3.5%, 5.4%, and 11.1%, respectively, versus 6.0%, 12.5%, and 17.6% in the 24 Gy cohort, respectively (p=.008).
- Risk of VCF was 5.5%, 7.6%, and 10.7% at 6, 12, and 24 months, respectively, and was similar between cohorts (p=.573).

Dose escalation to 28 Gy in 2 daily fractions was associated with improved local control without increasing the risk of VCF.

April 20, 2023

Stereotactic Radiosurgery vs Conventional Radiotherapy for Localized Vertebral Metastases of the Spine

Phase 3 Results of NRG Oncology/RTOG 0631 Randomized Clinical Trial

Samuel Ryu, MD[1]; Snehal Deshmukh, MS[2,3]; Robert D. Timmerman, MD[4]; et al

POPULATION

184 Men, 155 Women

Adults with 1 to 3 newly diagnosed vertebral metastases

Mean age, 62.6 y (range, 23-93 y)

INTERVENTION

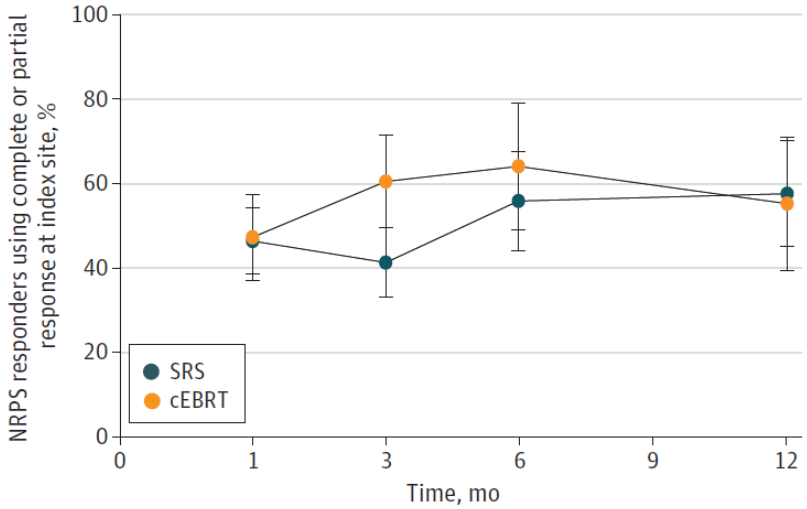
214 Participants randomized and analyzed at 3 mo

138 Stereotactic radiosurgery (SRS)
16-Gy or 18-Gy single-dose SRS delivered to the involved spine only

76 Conventional external beam radiotherapy (cEBRT)
8-Gy single-dose cEBRT administered to the involved spine plus 1 spine segment above and below

primary endpoint: 3-point improvement on NRPS

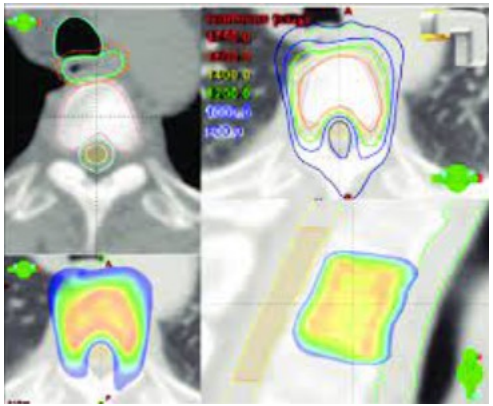
Figure 2. Numerical Rating Pain Scale Response Proportion at the Index Spine With No Increase in Pain Medication and No Progressive Pain at the Other Treated Spine

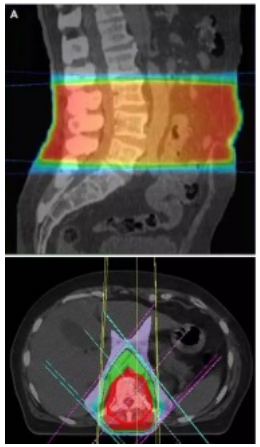


No. at risk				
SRS	153	138	68	59
cEBRT	93	76	39	38

The primary end point of pain response at 3 months favored cEBRT (41.3%for SRS vs 60.5%for cEBRT; difference,–19 percentage points; 95%CI, –32.9 to –5.5; 1-sided *P* = .99; 2-sided *P* = .01).

There were no differences in the proportion of acute or late adverse effects. Vertebral compression fracture at 24 months was 19.5%with SRS and 21.6%with cEBRT (*P* = .59).





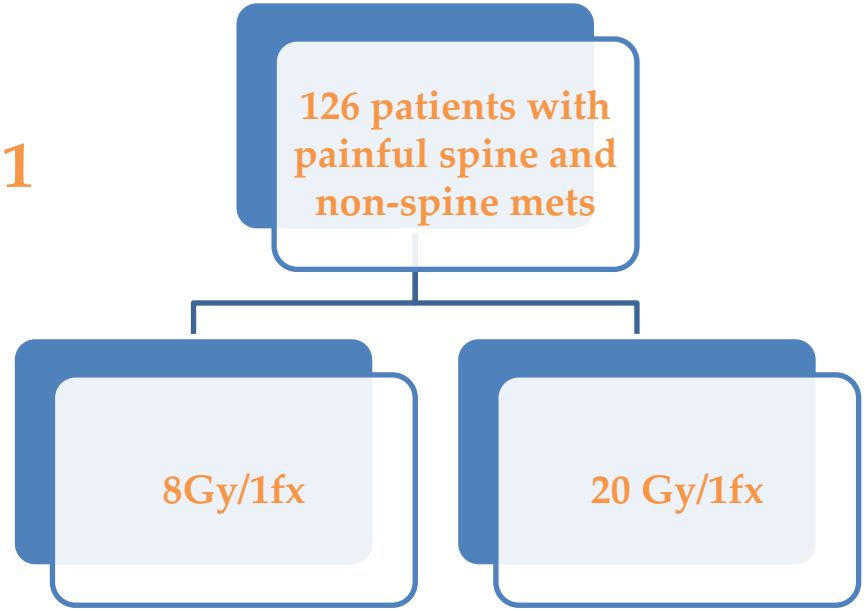
Discrepancies in volume delineation

Low SBRT dose

Discrepancy in pain assessment

ROBOMET trial

Primary endpoint: CR at 1 month

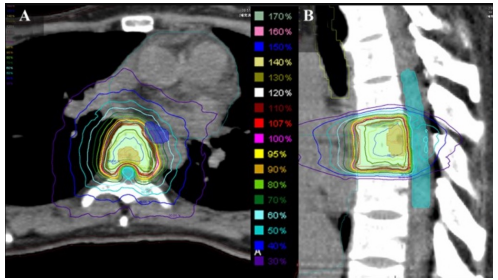


1 month ITT	3D CRT			SBRT			
	n=63	%	95%CI	n=63	%	95%CI	
CR	16	25%	15%-38%	23	37%	25%-50%	p=.25
PR	23	37%		21	33%		
IR	15	24%		14	22%		
PP	9	14%		5	8%		
3month ITT	3DCRT			SBRT			
	n=63	%	95%CI	n=63	%	95%CI	
CR	15	24%	14%-36%	21	33%	22%-46%	p=.32
PR	13	21%		11	17%		
IR	17	27%		9	14%		
PP	18	29%		22	35%		

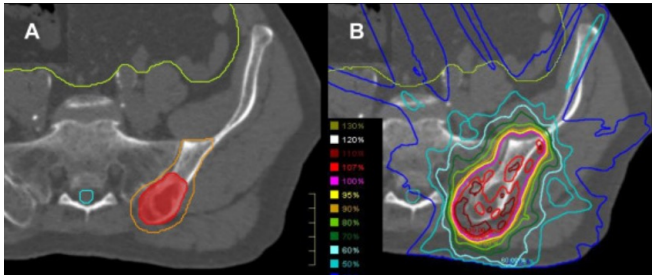
CR: complete response; IR: indeterminate response; ITT: intention-to-treat; PP: pain progression; PR: partial response

ROBOMET trial presented at ESTRO 2023

- 28% spine metastases



- 72% non-spine metastases



Per protocol analysis at 3 months showed higher CR rates in the SBRT arm vs 3DCRT (p=0.048)

ESTRO 2023 12-16 May 2023 Vienna, Austria

AIRO2023

Radioterapia Oncologica:
l'evoluzione al servizio dei pazienti

Stereotactic Body Radiation Therapy versus Conventional External Beam Radiotherapy for Spinal Metastases: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

Henry C. Y. Wong [1] • Shing Fung Lee [1] • Adrian Wai Chan • Saverio Caini • Peter Hoskin • Charles B. Simone II • Peter Johnstone • Yvette van der Linden • Joanne M. van der Velden • Emily Martin • Sara Alcorn • Candice Johnstone • J. Isabelle Choi • Gustavo Nader Marta • Eva Oldenburger • Srinivas Raman • Agata Rembielak • Vassilios Vassiliou • Pierluigi Bonomo • Quynh-Nhu Nguyen • Edward Chow • Samuel Ryu • Show less • Show footnotes

Published: September 20, 2023 • DOI: https://doi.org/10.1016/j.radonc.2023.109914

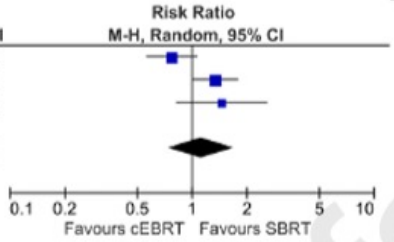
- SBRT does not provide better overall pain response compared to cEBRT.
- Complete pain response may be better with SBRT compared to cEBRT.
- Spine SBRT is safe and has similar side effect profile compared to cEBRT.
- Further studies are needed to determine which patients benefit most from spine SBRT.

First Author (Year)	Overall pain response at 3 months		Complete pain response at 3 months		Overall pain response at 6 months or beyond		Complete pain response at 6 months		Local progression*	
	SBRT	cEBRT	SBRT	cEBRT	SBRT	cEBRT	SBRT	cEBRT	SBRT	cEBRT
Sprave et al. (2018) (9)	53.3%	36.7%	33.30%	13.30%	46.70%	23.30%	33.30%	6.70%	NR	NR
Sahgal et al. (2021) (10)	52.6%	39.1%	35.10%	13.90%	41.20%	31.30%	32.50%	15.70%	2.6%	10.4%
Ryu et al. (2023) (11)	26.3%	33.8%	NR	NR	15.70%	15.40%	NR	NR	33.9%	42.3%

A

Study or Subgroup	SBRT Events	SBRT Total	cEBRT Events	cEBRT Total	Weight	Risk Ratio M-H, Random, 95% CI
Ryu et al. 2023	57	217	46	136	36.7%	0.78 [0.56, 1.07]
Sahgal et al. 2021	60	114	45	115	38.6%	1.35 [1.01, 1.79]
Sprave et al. 2018	16	30	11	30	24.7%	1.45 [0.82, 2.59]
Total (95% CI)		361		281	100.0%	1.12 [0.74, 1.70]
Total events	133		102			

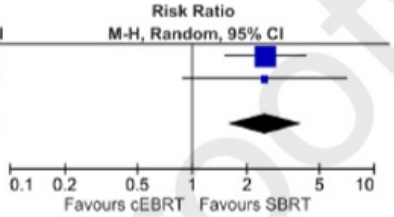
Heterogeneity: Tau² = 0.09; Chi² = 7.29, df = 2 (P = 0.03); I² = 73%
Test for overall effect: Z = 0.54 (P = 0.59)



B

Study or Subgroup	SBRT Events	SBRT Total	cEBRT Events	cEBRT Total	Weight	Risk Ratio M-H, Random, 95% CI
Sahgal et al. 2021	40	114	16	115	80.2%	2.52 [1.50, 4.24]
Sprave et al. 2018	10	30	4	30	19.8%	2.50 [0.88, 7.10]
Total (95% CI)		144		145	100.0%	2.52 [1.58, 4.01]
Total events	50		20			

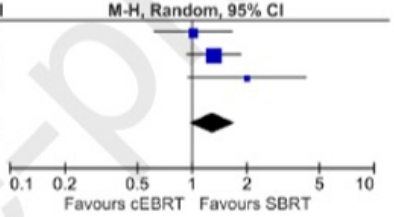
Heterogeneity: Tau² = 0.00; Chi² = 0.00, df = 1 (P = 0.99); I² = 0%
Test for overall effect: Z = 3.90 (P < 0.0001)

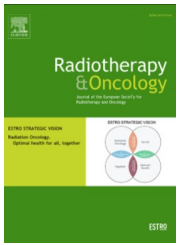


C

Study or Subgroup	SBRT Events	SBRT Total	cEBRT Events	cEBRT Total	Weight	Risk Ratio M-H, Random, 95% CI
Ryu et al. 2023	34	217	21	136	30.0%	1.01 [0.62, 1.67]
Sahgal et al. 2021	47	114	36	115	56.0%	1.32 [0.93, 1.87]
Sprave et al. 2018	14	30	7	30	14.0%	2.00 [0.94, 4.25]
Total (95% CI)		361		281	100.0%	1.29 [0.97, 1.72]
Total events	95		64			

Heterogeneity: Tau² = 0.01; Chi² = 2.21, df = 2 (P = 0.33); I² = 9%
Test for overall effect: Z = 1.74 (P = 0.08)

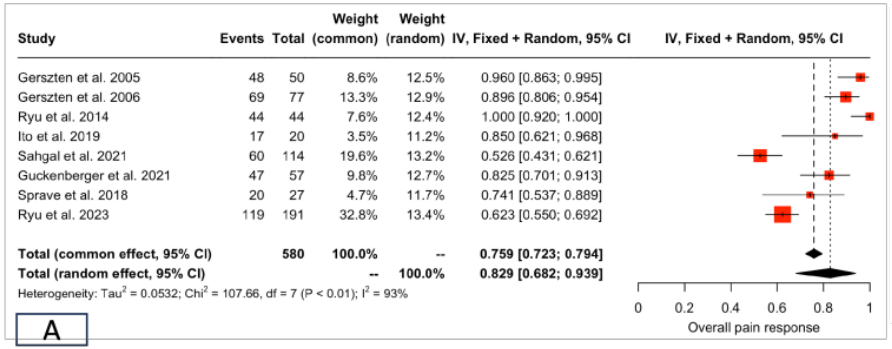


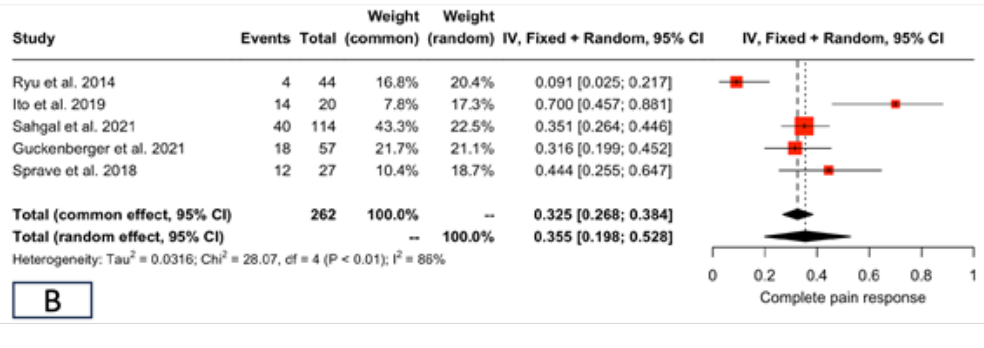


https://doi.org/10.1016/j.radonc.2023.109914

Efficacy and safety for SBRT for spine metastases: A systematic review and meta-analysis for preparation of an ESTRO practice guideline

RS Guninski[1], F Cuccia[2], F Alongi[3], N Andratschke[1], C Belka[4], D Bellut[5], M Dahele[6], M Josipovic[7,8], TE Kroese[1], P Mancosu[9], G Minniti[10], M Niyazi[4], U Ricardi[11], PM Af Rosenschöld[12], A Sahgal[13], Y Tsang[14], W Verbakel [15], M Guckenberger[1]





Accepted on Radiotherapy and Oncology

Efficacy and safety for SBRT for spine metastases: A systematic review and meta-analysis for preparation of an ESTRO practice guideline

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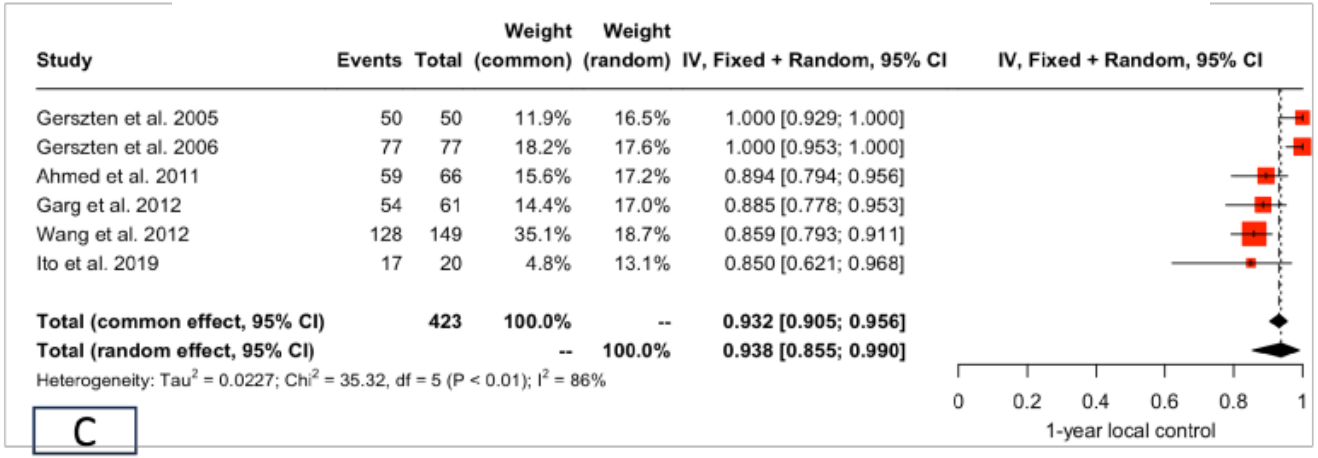


Study	Events	Total	Weight (common)	Weight (random)	IV, Fixed + Random, 95% CI
Gerszten et al. 2005	50	50	11.9%	16.5%	1.000 [0.929; 1.000]
Gerszten et al. 2006	77	77	18.2%	17.6%	1.000 [0.953; 1.000]
Ahmed et al. 2011	59	66	15.6%	17.2%	0.894 [0.794; 0.956]
Garg et al. 2012	54	61	14.4%	17.0%	0.885 [0.778; 0.953]
Wang et al. 2012	128	149	35.1%	18.7%	0.859 [0.793; 0.911]
Ito et al. 2019	17	20	4.8%	13.1%	0.850 [0.621; 0.968]
Total (common effect, 95% CI)		**423**	**100.0%**	--	**0.932 [0.905; 0.956]**
Total (random effect, 95% CI)			--	**100.0%**	**0.938 [0.855; 0.990]**

Heterogeneity: $Tau^2 = 0.0227$; $Chi^2 = 35.32$, df = 5 ($P < 0.01$); $I^2 = 86\%$

C

Accepted on Radiotherapy and Oncology

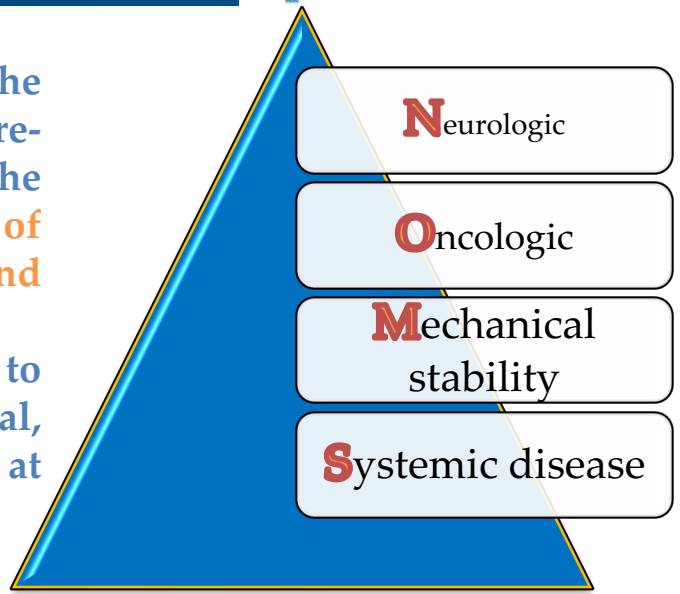
FULL LENGTH ARTICLE | VOLUME 34, ISSUE 5, P325-331, MAY 01, 2022

The Changing Landscape for the Treatment of Painful Spinal Metastases: is Stereotactic Body Radiation Therapy the New Standard of Care?

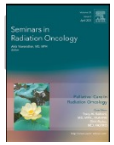
E.M. Dunne • M.C. Liu • S.S. Lo • A. Sahgal

Careful patient selection is required to determine the appropriateness for spine SBRT, especially in the re-treatment setting. All decisions need to be made in the context of patient performance status, the degree of systemic disease, the timeframe of local relapse and previous radiation exposure.

The NOMS guidelines provide a good general approach to patients with spinal metastases based upon neurological, oncological, mechanical and systemic status at presentation.



Stereotactic Body Radiation Therapy for Spinal Metastases: Benefits and Limitations



Matthias Guckenberger, MD,* Max Dahele, MBChB, PhD,† Wee Loon Ong, MBBS,‡,§ and Arjun Sahgal, MD‡

Table 1 Workflow Process for Spine SBRT

Pre-treatment assessments
Clinical examination including neurological function assessment
Quantitative pain assessment using validated instruments such as the visual analogue scale (VAS) or brief pain inventory (BPI)
Spinal instability assessment using the Spinal Instability Neoplastic Score (SINS)
Epidural spinal cord compression assessment using the score developed by Bilsky et al.
SBRT planning
High-resolution CT imaging
High-resolution MR imaging: T1 without contrast; T1 with contrast in presence of paraspinal or epidural disease; T2 non-contrast
Careful rigid image-registration
Target volume definition following international consensus recommendations
IMRT treatment planning
VMAT and flattening-filter-free (FFF) technologies to minimize SBRT delivery times
Daily pre-treatment image-guided patient set-up
Passive or active intra-fraction motion control
Follow-up
Clinical follow-up using pre-treatment assessments
Imaging follow-up using high-resolution CT and / or MR imaging

https://doi.org/10.1016/j.semradonc.2022.11.006

National Comprehensive Cancer Network®

NCCN Guidelines Version 1.2023
Central Nervous System Cancers

NCCN Guidelines Index
Table of Contents
Discussion

PRINCIPLES OF RADIATION THERAPY FOR BRAIN AND SPINAL CORD

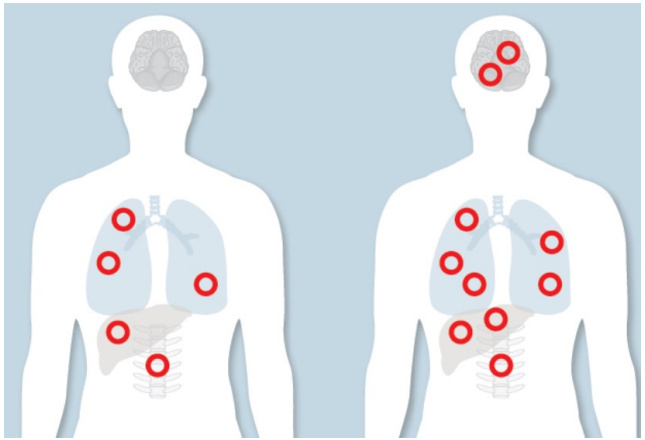
Metastatic Spine Tumors

- General Treatment Information
  - Doses to vertebral body metastases will depend on patient's PS, spine stability, location in relationship to spinal cord, primary histology, presence of epidural disease, and overall treatment intent (pain relief, long-term local control, or cure).
  - Stereotactic radiation approaches (SRS/stereotactic body radiotherapy [SBRT]) for spinal cases may be preferred for patients with life expectancy ≥3 months where tumor ablation is a goal of treatment, in tumors considered radioresistant (eg, renal cell, melanoma, sarcoma, hepatocellular, some colorectal and NSCLC cases), and in select patients for optimal pain relief.
  - Stereotactic radiation approaches may also be preferred in the setting of tumor recurrence after prior radiation as a strategy to limit radiation dose to the spinal cord or other critical structures. Careful adherence to consensus guidelines for radiosurgery planning and delivery is recommended.[35-37]

Review > Jpn J Radiol. 2022 Oct;40(10):1017-1023. doi: 10.1007/s11604-022-01277-y.
Epub 2022 Apr 9.

Stereotactic body radiotherapy for spinal oligometastases: a review on patient selection and the optimal methodology

Kei Ito [1], Yujiro Nakajima [2 3], Syuzo Ikuta [2]



Dose fractionation	2-y LC rate (%)
16 Gy/1 Fr [8]	72
27 Gy/3 Fr [32]	78
18 Gy/1 Fr [8]	82
35 Gy/5 Fr [8]	83
30 Gy/3 Fr [32]	85
20 Gy/1 Fr [8]	90
24 Gy/1 Fr [32]	96

LC local control, *y* year, *Fr* fraction

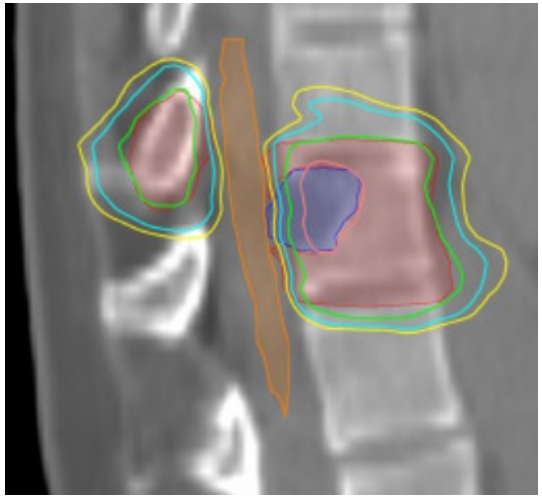
Review > Jpn J Radiol. 2022 Oct;40(10):1017-1023. doi: 10.1007/s11604-022-01277-y.
Epub 2022 Apr 9.

Stereotactic body radiotherapy for spinal oligometastases: a review on patient selection and the optimal methodology

Kei Ito [1], Yujiro Nakajima [2 3], Syuzo Ikuta [2]

Trial	*N*	Primary site	Number of metastases	Primary endpoint
NRG BR-002 [9]	402	Breast cancer	≤4	8-y OS
NRG LU-002 [10]	300	Lung cancer	≤3	3-y OS
SARON [12]	340	Lung cancer	≤3	3-y OS
CORE [12]	245	Breast, lung, and prostate cancer	≤3	5-y PFS
SABR-COMET 3 [13]	297	Any	≤3	OS
SABR-COMET 10 [14]	159	Any	4–10	OS
STEREO-STEIN [15]	280	Breast cancer	≤5	3-y PFS

SBRT stereotactic body radiotherapy, *OS* overall survival, *PFS* progression-free survival, *y* year



Original Article

Volumetric Intensity-Modulated Arc Stereotactic Radiosurgery Boost in Oligometastatic Patients with Spine Metastases: a Dose-escalation Study

F. Deodato *†, D. Pezzulla *, S. Cilla ‡, M. Ferro *, R. Giannini §, C. Romano ‡, M. Boccardi *, M. Buwenge ¶||, V. Valentini †§, A.G. Morganti ¶||[1], G. Macchia *[1]

Dose level	Total dose/fractionation (Gy)		Planned lesions (*n*)	Treated lesions (*n*)	De-escalated lesions (*n*)
	PTV2	PTV1			
I	25/2.5 (31.2*)	8 (14.4)*	6	32	23
II	25/2.5 (31.2*)	10 (20.0)*	6	14	0
III	25/2.5 (31.2*)	12 (26.4)*	6	6	0

PTV, planning target volume; PTV1, macroscopic disease plus margin; PTV2, macroscopic disease, affected and contiguous vertebrae along the cranial caudal axis plus margin.

* Biological effective dose $\alpha/\beta 10$.

Fifty-two lesions accounting for 40 consecutive patients (male/female: 29/11; median age: 71 years; range 40e85) were treated from April 2011 to September 2020. Most patients had a primary prostate (65.0%) or breast cancer (22.5%). Thirty-two patients received 8 Gy VMAT-SRS boost (total BED a/b10: 45.6 Gy), 14 patients received 10 Gy (total BED a/b10: 51.2 Gy) and six patients received 12 Gy (total BED a/b10: 57.6 Gy).

https://doi.org/10.1016/j.clon.2022.09.045

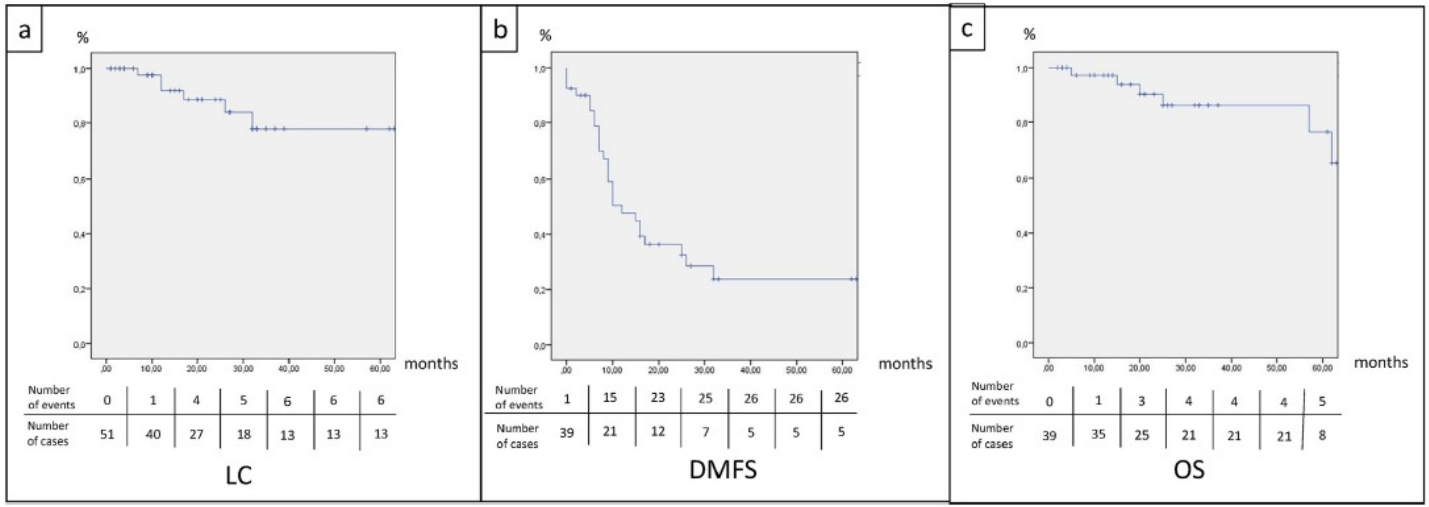


Fig 3. (a) Actuarial local control, (b) distant metastases-free survival, and (c) overall survival.

- Follow-up time=70 months (range 2-240 months)
- No acute toxicities > grade 2 and no late toxicities > grade 1 were recorded
- Overall response rate=78.8%
- 24-month LC, DMFS and OS rates=88.5%, 27.1% and 90.3%, respectively.

https://doi.org/10.1016/j.clon.2022.09.045

Patient characteristics (n = 128)	
Age, y, median (range)	62 (16-91)
Median follow-up, mo (range)	16.5 (1-118)
Systemic therapy (by lesion n = 191)	
Received immunotherapy	50 (26%)
Received systemic therapy	172 (90%)
Previous decompression surgery (by lesion n = 191)	
Yes	24 (13%)
No	167 (87%)
SBRT fractionation (by lesion n = 191)	
Single fraction (median dose, 16 Gy)	107 (56%)
Three fractions (median dose, 8 Gy)	84 (44%)
Histology (by lesion n = 191)	
NSCLC	35 (18%)
Breast	35 (18%)
Renal cell	26 (14%)
Prostate	18 (9%)
Melanoma	13 (7%)
Head and neck	12 (6%)
Sarcoma	9 (5%)
Myeloma	8 (4%)
Other	35 (18%)

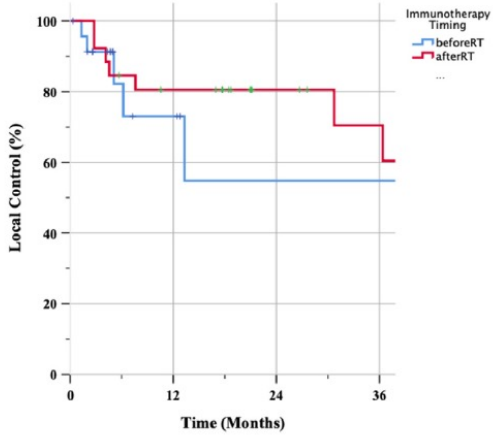
Abbreviations: IT = immunotherapy; NSCLC = non-small cell lung cancer; SBRT = stereotactic body radiation therapy.

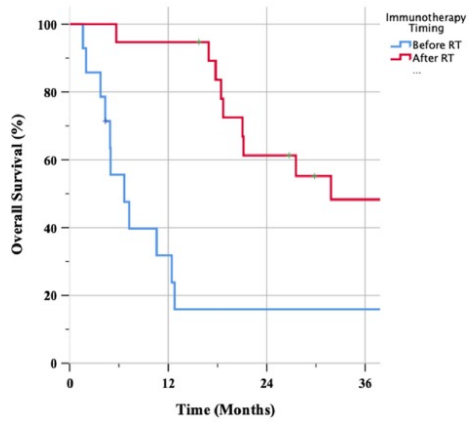
Effect of Immunotherapy and Stereotactic Body Radiation Therapy Sequencing on Local Control and Survival in Patients With Spine Metastases

Jacob Eckstein, MD,[a] Emile Gogineni, DO,[b] Baho Sidiqi, MD,[a] Noah Lisser, BS,[a] and Bhupesh Parashar, MD, DrPH[a,*]

advances in radiation oncology

ASTRO





Sequencing of IT and SBRT was not associated with any difference in LC or toxicity, but delivering IT after SBRT versus before SBRT was associated with improved OS.

Advances in Radiation Oncology (2023) 8, 101179

Stereotactic body radiotherapy for spine oligometastases: a multicenter retrospective study from Italian Association of Radiotherapy and Clinical Oncology (AIRO)

Francesco Cuccia • Edoardo Pastorello • Ciro Franzese • Liliana Belgioia • Mario Bignardi • Manuela Federico • Vanessa Figlia • Niccolò Giaj Levra • Serena Badellino • Paolo Borghetti • Giulia Marvaso • Giampaolo Montesi • Antonio Pontoriero • Ivan Fazio • Giuseppe Ferrera • Filippo Alongi • Marta Scorsetti •

- From March 2018 to July 2022, 183 lesions in 177 patients.
- The most frequent primary histology were prostate cancer in 57%, breast in 26%, lung cancer in 9.6%;
- Oligometastases were oligorecurrent (59%), oligoprogressive (30%) or oligopersistent (11%).
- In the majority of patients, SBRT was delivered to a single spine metastasis (82%), 2 in 10%, and 3 lesions in 8%, with thoracic spine being the most frequent site of treatment (61.7%)

Published: September 07, 2023 • DOI: https://doi.org/10.1016/j.clon.2023.09.001

Characteristics	n
Site of the column	Cervical=9; thoracic=113; lumbar=61
Site of the vertebra	Body=157; transverse process=13; posterior peduncle=13
Pain prior to SBRT	Yes=26; no=151
Concurrent systemic therapy	Hormone therapy=62; target therapy=11; immunotherapy=5; chemotherapy=32; parp-inhibitors=11
Imaging pre-SBRT	PET=112; MRI=24; both=34; other=13
Median total dose and fractions	21 Gy (14-35)/3 fx (1-5)
Median BED	119 Gy (57.5-152 Gy)
Technique	VMAT=169; HT=14
Median follow-up	18 months (3-96)

	1year	2years	3years
LC	90.3%	84.3%	84.3%
DPFS	33.1%	18.5%	12.4%
PMFS	57.8%	43.4%	32.4%
OS	91.8%	79.6%	65.9%

Table 8 - Local control rate and dose fraction schedules used in randomized trials for spine oligometastases

Dose fractionation	2-years LC%
16 Gy/1 Fr[5,16]	72
27 Gy/3 Fr[20]	78
18 Gy/1 Fr[5,16]	82
35 Gy/5 Fr[5,16]	83
30 Gy/3 Fr[20]	85
20 Gy/1 Fr[5,16]	90
24 Gy/1 Fr[20]	96
21 Gy/3 Fr (present study)	84.3

Local control

- At univariate analysis (UA), prostate histology, oligorecurrent disease and the synergistic use of PET- and MRI-imaging for target volume delineation were found as predictive factors for LC (p=0.002, p=0.09 and p=0.0016), at multivariate analysis (MA), only prostate histology kept significance (p=0.006).

Distant progression-free survival

- Prostate histology (p=0.023), oligorecurrent disease (p=0.04) and BED_{10}>100Gy (p=0.04) found as predictive at UA

Polymetastases-free survival

- Oligorecurrent disease (p=0.001) and concurrent systemic therapy (p=0.0017) being significant for better rates at UA. Only concurrent therapy kept significance at MA (p=0.009).
- A further oligometastatic progression was observed in 33 patients (18.6%) treated with a second course of SBRT, reporting at UA slightly improved polymetastatic disease-free (PMS) and overall survival (OS) rates (p=0.07 and p=0.01)

Overall survival

- Prostate and non-cervical metastases related to better OS at MA (p=0.05 and p=0.015).

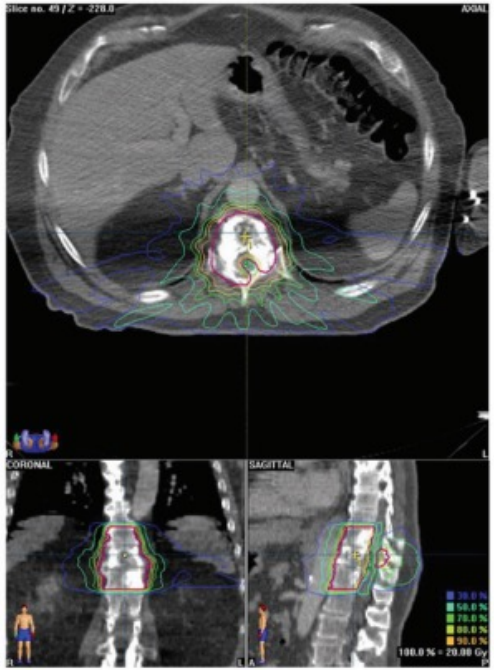
Toxicity and Adverse Events

- Pain flare in 3.3%, 5 patients developed vertebral fracture after SBRT, no other G3 or higher adverse event

J Radiosurg SBRT. 2014;3(1):51-58.

Stereotactic radiosurgery for high-grade metastatic epidural cord compression

Ian Lee [1], Melvin Omodon [1], Jack Rock [1], Lonni Shultz [1 2], Samuel Ryu [1 3]

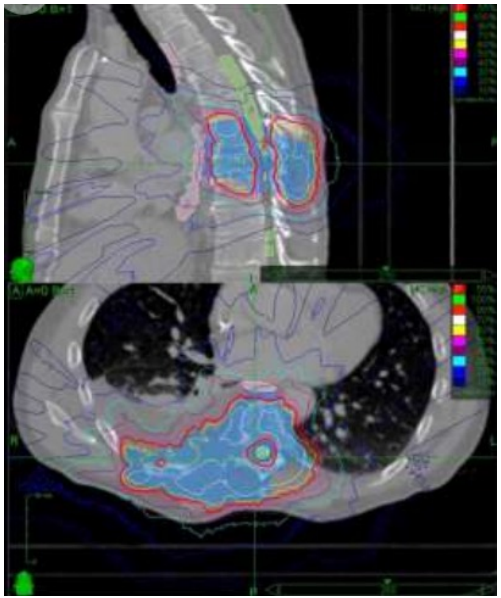


33 patients with 35 metastatic lesions causing Ryu/Rock radiographical grade IV or V compression

Radiosurgery doses ranged from 14-20 Gy

Overall, epidural tumor response rate was 80% (complete response 27%, partial response 30%, and minimal response 23%), with progression seen in 6%.

Overall, 85% remained intact or ambulatory after radiosurgery. Notably, 94% of the patients who were intact before radiosurgery remained so. Of the 27 patients who presented with neurological deficit, 52% (14/27) had complete recovery to normal, 11% (3/27) improved, and 11% (3/27) remained stable



Oncologic and Functional Outcomes after Stereotactic Body Radiation Therapy for High-Grade Malignant Spinal Cord Compression

Palak P. Patel, B.S. • Yilin Cao, M.D. • Xuguang Chen, M.D. • ... Sang H. Lee, M.D., Ph.D. • Daniel Lubelski, M.D. • Kristin J. Redmond, M.D., M.P.H. • Show all authors

Open Access • Published: July 28, 2023 • DOI: https://doi.org/10.1016/j.adro.2023.101327

advances in radiation oncology

ASTRO

143 patients with Bilsky grade 2-3 MESCC from solid tumor metastases treated with SBRT at a single institution during 2009 - 2020 were retrospectively reviewed. Patients who received upfront surgery prior to SBRT were included only if post-surgical Bilsky grade remained >2.

6 Gy x 5 (28.0%), 5 Gy x 5 (21.0%), and 9 Gy x 3 (17.5%). The mean BED10 delivered was 44.4 Gy. The median prescription isodose line was 60% (range: 50%-85%)

- The cumulative incidence of LR was 5.1%, 7.5% and 14.1% at 6, 12 and 24 months, respectively.

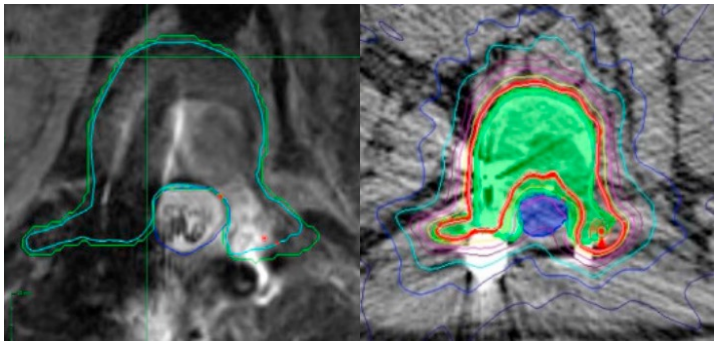
- At first post-SBRT imaging, 16.2% of patients with initial Bilsky grade 2 improved to grade 1 while 53.8% patients were stable. Five of 13 patients (38.4%) with initial Bilsky grade 3 improved to grade 1-2.

- Pain response at 3 and 6 months post-SBRT was complete in 45.4% and 55.7%, partial in 26.9% and 13.1%, stable in 24.1% and 27.9%, and worse in 3.7% and 3.3% of patients, respectively.

- At 3 and 6 months after SBRT, 17.8% and 25.0% of patients had improved ambulatory status and 79.7% and 72.4% had stable status.

Phase 2 Clinical Trial of Separation Surgery Followed by Stereotactic Body Radiation Therapy for Metastatic Epidural Spinal Cord Compression

Kei Ito [1], Shurei Sugita [2], Yujiro Nakajima [3], Tomohisa Furuya [3], Ogawa Hiroaki [3], Sara Hayakawa [3], Takahiro Hozumi [2], Makoto Saito [4], Katsuyuki Karasawa [3]



Clinical Trial > Int J Radiat Oncol Biol Phys. 2022 Jan 1;112(1):106-113.
doi: 10.1016/j.ijrobp.2021.07.1690. Epub 2021 Oct 26.

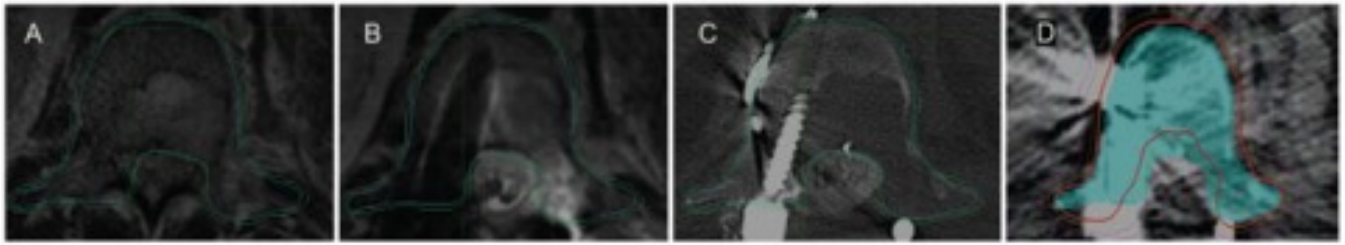
The protocol for treatments comprised preoperative embolization, separation surgery, and spine SBRT. The prescribed dose for spine SBRT was 24 Gy in 2 fractions. The primary endpoint was the 12-month local failure rate. 33 patients enrolled

The 12-month local failure rate was 13%. Radiation-induced myelopathy, radiculopathy, and vertebral compression fracture were observed in 0, 1, and 6 patients, respectively.

Stereotactic Radiosurgery for Postoperative Spine Malignancy: A Systematic Review and International Stereotactic Radiosurgery Society Practice Guidelines

Salman Faruqi, MD,[a,*] Hanbo Chen, MD,[b] Laura Fariselli, MD,[c] Marc Levivier, MD, PhD,[d] Lijun Ma, PhD,[e] Ian Paddick, PhD,[f] Bruce E. Pollock, MD,[g] Jean Regis, MD,[h] Jason Sheehan, MD,[i] John Suh, MD,[j] Shoji Yomo, MD, PhD,[k] and Arjun Sahgal, MD[b]

- An MRI fused to the planning CT, or the use of a CT-myelogram, are necessary for target and organ-at-risk delineation.
- A planning organ-at-risk volume (PRV) of 1.5-2 mm for the spinal cord is advised.
- Post-operative spine SBRT delivers a high 1-year LC with acceptably low toxicity.
- Patients who may benefit from this include those with oligometastatic disease, radioresistant histology, paraspinal masses, or those with a history of prior irradiation to the affected spinal segment.
- The International Stereotactic Radiosurgery Society recommends a minimum interval of 8 to 14 days after invasive surgery before simulation for SBRT, with initiation of radiation therapy within 4 weeks of surgery.



Spinal cord constraints

International Journal of Radiation Oncology biology • physics
www.redjournal.org

Consensus guidelines for postoperative stereotactic body radiation therapy for spinal metastases: results of an international survey

Kristin J. Redmond, MD, MPH[1], Simon S. Lo, MD[2], Scott G. Soltys, MD[3], Yoshiya Yamada, MD[4], Igor J. Barani, MD[5], Paul D. Brown, MD[6], Eric L. Chang, MD[7], Peter C. Gerszten, MD[8], Samuel T. Chao, MD[9], Robert J. Amdur, MD[10], Antonio A. F. De Salles, MD, PhD[11], Matthias Guckenberger, MD[12], Bin S. Teh, MD[13], Jason Sheehan, MD, PhD[14], Charles R. Kersh, MD[15], Michael G. Fehlings, MD, PhD, FRCSC[16], Moon-Jun Sohn, MD, PhD[17], Ung-Kyu Chang, MD[18], Samuel Ryu, MD[19], Iris C. Gibbs, MD[3], and Arjun Sahgal, MD, FRCPC[20]

Prior Conventional RT dose	1 Fraction	2 Fractions	3 Fractions	4 Fractions	5 Fractions
No prior RT & no cord compromise	10–14 Gy D_{max} 10 Gy to <10% cord *	17 Gy D_{max}	18–21 Gy D_{max}	23–26 Gy D_{max}	25–30 Gy D_{max}
No prior RT but cord compromise	8–14 Gy D_{max} 10 Gy to <10% cord *	17 Gy D_{max}	18–21 Gy D_{max}	23–26 Gy D_{max}	25–28 Gy D_{max}
800 cGy in 1 fraction	9 Gy D_{max}	12.2 Gy D_{max}	14–21 Gy D_{max}	16.2 Gy D_{max}	17. 5 –27. 5 D_{max}
2000 cGy in 5 fractions	9–12 Gy D_{max}	12.2 Gy D_{max}	14–21 Gy D_{max}	16.2 Gy D_{max}	15–27.5 Gy D_{max}
3000 cGy in 10 fractions	9–12 Gy D_{max}	12.2 Gy D_{max}	14–21 Gy D_{max}	16.2 Gy–24 Gy D_{max}	17.5–26 Gy D_{max}
4000 cGy in 20 fractions	9–12 Gy D_{max}	12.2 Gy D_{max}	14–21 Gy D_{max}	16.2 Gy D_{max}	12–25 Gy D_{max}
4500 cGy in 25 fractions	9–12 Gy D_{max}	12.2 Gy D_{max}	14–21 Gy D_{max}	16.2 Gy D_{max}	12–18 Gy D_{max}

CLINICAL INVESTIGATION Int. J. Radiation Oncology Biol. Phys., Vol. 66, No. 5, pp. 1446–1449, 2006 Normal Tissue

UPDATE OF HUMAN SPINAL CORD REIRRADIATION TOLERANCE BASED ON ADDITIONAL DATA FROM 38 PATIENTS

CARSTEN NIEDER, M.D., ANCA L. GROSU, M.D., NICOLAUS H. ANDRATSCHKE, M.D., AND MICHAEL MOLLS, M.D.

Department of Radiation Oncology, Klinikum rechts der Isar der Technischen Universität München, Munich, Germany

Risk score for development of radiation myelopathy from reference (1)

Factor	0 points	1 point	2 points	3 points	4 points	5 points	6 points	7 points	8 points	9 points
Cumulative BED in Gy_2	≤120	120.1–130	130.1–140	140.1–150	150.1–160	160.1–170	170.1–180	180.1–190	190.1–200	>200
Interval <6 months					× (4.5)					
BED of one course ≥102 Gy_2					× (4.5)					

When the interval between the two treatment courses is not shorter than 6 months and the dose of each course is <98 Gy_2, the cumulative BED where no case of RM has yet been reported is 120 Gy_2, however doses ranging between 130-150 Gy_2 appear justified in situations where limited target volume doses might compromise the goal of tumor control, if the patient accepts a higher risk of myelopathy.

Author, Year	Study Design	Patients/ Lesions (N)	Histology	Prior RT (%)	Total Dose	Fractions (N)	Pain Relief (%)	Local Control (%)	Follow-up (mo)
Gerszten et al,[32] 2007	Retrospective	NA/344	Mixed	100%	20 (12.5–25)	1	86 (in entire 500-lesion cohort)	88	21 (3–53)
Sahgal et al,[41] 2009	Retrospective	39/60	Mixed	62%	24	3	NA	87	8 (1–48)
Choi et al,[42] 2010	Retrospective	42/51	Mixed	100%	20 (10–30)	2 (1–5)	65	74	7 (2–47)
Mahadevan et al,[43] 2011	Retrospective	60/81	Mixed	100%	24 (24–35)	3 (3–5)	65	93	12 (4–36)
Garg et al,[44] 2011	Prospective	59/63	Mixed	100%	NA (27–30)	NA (3–5)	NA	76	18 (NA)
Nikolajek et al,[45] 2011	Retrospective	54/70	Mixed	100%	18 (10–28)	1	86	87	14 (3–48)
Chang et al,[40] 2012	Retrospective	NA/54	Mixed	100%	27 (mean SF equivalent 20.6)	3 (NA)	78	81	22 (NA)
Thibault et al,[46] 2015	Retrospective	40/56	Mixed	100%	30 (20–35)	NA (2–5)	NA	78	7 (1–39)
Hashmi et a,[47] 2016	Retrospective	215/247	Mixed	100%	18 (16–24)	1 (1–3)	74	87	8
Boyce-Fappiano et al,[48] 2017	Retrospective	162/237	Mixed	100%	16 (16–35)	1 (1–5)	81	71	10

Follow-up range: 7-22 months; LC rates range: 71-93%

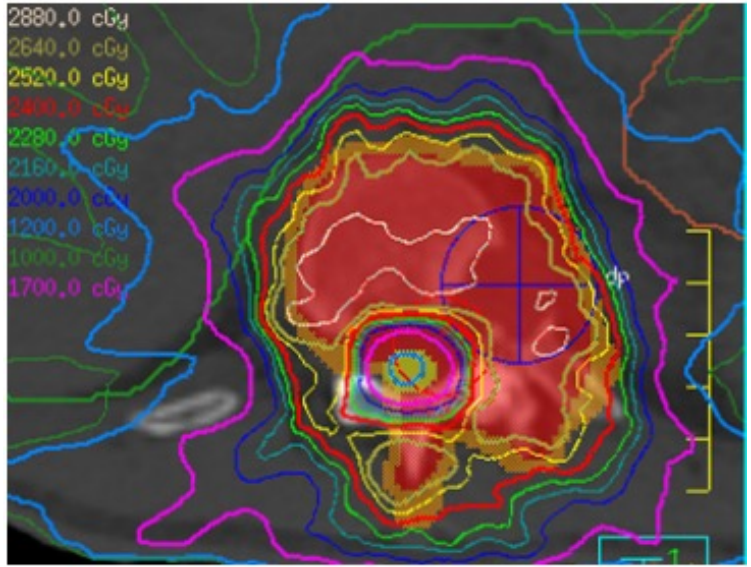
Moraes et al, Neurosurg Clin N Am, 2020

Reirradiation of the spine with stereotactic radiosurgery: Efficacy and toxicity

David Boyce-Fappiano BSc [a], Erinma Elibe BS [a], Bo Zhao PhD [a], M. Salim Siddiqui MD, PhD [a], Ian Lee MD [b], Jack Rock MD [b], Samuel Ryu MD [c], Farzan Siddiqui MD, PhD [a]

https://doi.org/10.1016/j.prro.2017.05.007

- 237 previously irradiated lesions in 162 patients
- Median time between courses of RT was 10.2 months.
- Median SRS dose was 16 Gy in 1 fraction.
- Median conventional cEBRT dose was 30 Gy in 10 fractions.



Overall pain, neurological, and radiographic response rates were 81%, 82%, and 71%, respectively.

Neuro-Oncology Practice
7(S1), i45–i53, 2020 | doi:10.1093/nop/npaa045

Management of recurrent or progressive spinal metastases: reirradiation techniques and surgical principles

Rupesh Kotecha*, Nicolas Dea*, Jay S. Detsky, and Arjun Sahgal

Table 3. Stereotactic Radiosurgery/Stereotactic Body Radiotherapy Reirradiation Dose and Fractionation Schedules and Spinal Cord/Thecal Sac Safety Constraints With a Low Expected Incidence of Radiation Myelopathy[24,26,29]

Recommended treatment dose/ fractionation	18-24 Gy/1 fx	24 Gy/2 fx	27-30 Gy /3 fx	30 Gy/4 fx	40 Gy/5 fx
None	12.4-14 Gy spinal cord 16 Gy cauda equina	17 Gy	20.3 Gy	23 Gy	25.3 Gy
20 Gy/5 fx (30 Gy [2/2])	9 Gy	12.2 Gy	14.5 Gy	16.2 Gy	18 Gy
30 Gy/10 fx (37.5 Gy [2/2])	9 Gy	12.2 Gy	14.5 Gy	16.2 Gy	18 Gy
37.5 Gy/15 fx (42 Gy [2/2])	9 Gy	12.2 Gy	14.5 Gy	16.2 Gy	18 Gy
40 Gy/20 fx (40 Gy [2/2])	NA	12.2 Gy	14.5 Gy	16.2 Gy	18 Gy
45 Gy/25 fx (43 Gy [2/2])	NA	12.2 Gy	14.5 Gy	16.2 Gy	18 Gy
50 Gy/25 fx (50 Gy [2/2])	NA	11 Gy	12.5 Gy	14 Gy	15.5 Gy

Abbreviations: BED, biologically effective dose; fx, fraction; NA, not available.
Assumes maximum (0.03-cc) dose to spinal cord planning risk volume or thecal sac.

A phase 2 trial is currently evaluating single-fraction SBRT to multifraction SBRT as salvage treatment for previously irradiated spinal metastases (NCT03028337)

Single Versus Multifraction Salvage Spine Stereotactic Radiosurgery for Previously Irradiated Spinal Metastases

ClinicalTrials.gov Identifier: NCT03028337

Recruitment Status : Recruiting
First Posted : January 23, 2017
Last Update Posted : September 26, 2022

See Contacts and Locations

Sponsor:

M.D. Anderson Cancer Center

U.S. National Library of Medicine

ClinicalTrials.gov

Spine Radiosurgery - 1 Dose: For single fraction and multifraction arms, 0.01 cc of the cord allowed to receive 10 Gy and 14 Gy, respectively while 0.01 cc of the cauda equina allowed to receive 14 Gy and 18 Gy, respectively.

VS

Spine Radiosurgery - 3 Doses (3 days): The dose for the multifraction arm is 27 Gy in 3 fractions (9 Gy per fraction).

Primary endpoint: Time to local failure
Secondary endpoint: Pain relief

REVIEW ARTICLE

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Cumulative dose, toxicity, and outcomes of spinal metastases re-irradiation

Systematic review on behalf of the Re-Irradiation Working Group of the Italian Association of Radiotherapy and Clinical Oncology (AIRO)

Antonio Pontoriero[1] · Sara Lillo[2] · Luciana Caravatta[3] · Fabiana Bellafiore[4] · Silvia Longo[5] · Elisabetta Lattanzi[6] · Silvana Parisi[2] · Francesco Fiorica[7] · Mariangela Massaccesi[8]

Table 3 Significant predictors/prognostic factors for pain response, local control, survival, and toxicity in spinal re-irradiation

Outcome	Patient-related	Tumor-related	Treatment-related
Pain response	Time interval to reRT [23]	–	–
Local control	Time interval to reRT [15, 31]	Tumor proximity to CNS [14, 17] Presence/absence of paraspinal soft tissue disease [33] Presence of epidural disease [18, 31, 33] Tumor volume [18] Oligometastatic/polymetastatic disease [24]	Radiation dose 30 Gy/5 frx vs. 20 Gy/5 frx [28] Number of fractions [15]
Survival	Performance status [15, 16, 28] Time interval to reRT [15–17, 28, 33]	Tumor histology [16, 28] Presence of visceral metastases [15, 16] Oligometastatic disease [33]	–
Toxicity	Diabetes [29]	–	–

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Discussion

PRINCIPLES OF RADIATION THERAPY FOR BRAIN AND SPINAL CORD

Metastatic Spine Tumors

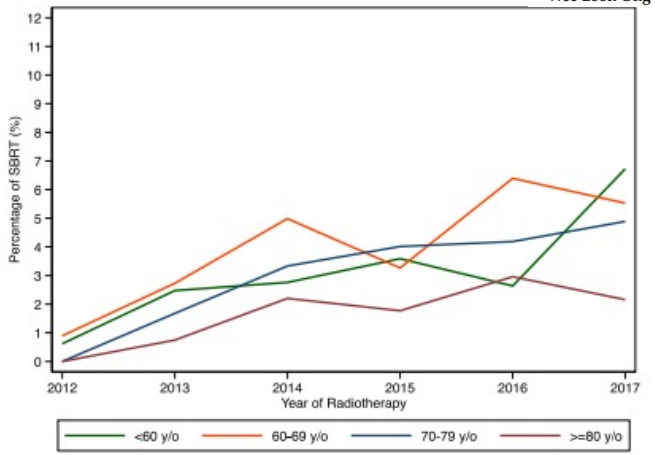
- General Treatment Information
  - Doses to vertebral body metastases will depend on patient's PS, spine stability, location in relationship to spinal cord, primary histology, presence of epidural disease, and overall treatment intent (pain relief, long-term local control, or cure).
  - Stereotactic radiation approaches (SRS/stereotactic body radiotherapy [SBRT]) for spinal cases may be preferred for patients with life expectancy ≥3 months where tumor ablation is a goal of treatment, in tumors considered radioresistant (eg, renal cell, melanoma, sarcoma, hepatocellular, some colorectal and NSCLC cases), and in select patients for optimal pain relief.
  - Stereotactic radiation approaches may also be preferred in the setting of tumor recurrence after prior radiation as a strategy to limit radiation dose to the spinal cord or other critical structures. Careful adherence to consensus guidelines for radiosurgery planning and delivery is recommended.[35-37]

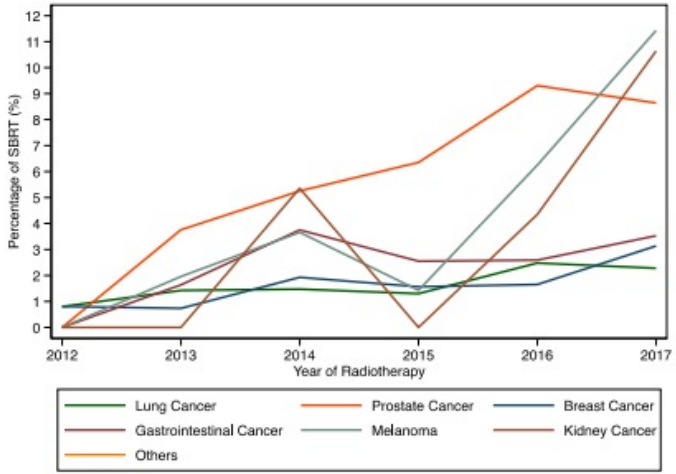
Current Oncology
MDPI

Article

Stereotactic Body Radiation Therapy for Spine Metastases—Findings from an Australian Population-Based Study

Wee Loon Ong [1,2,3,*], Roger L. Milne [4,5,6], Farshad Foroudi [7] and Jeremy L. Millar [1,2]





While SBRT is gradually becoming the standard-of-care in the management of painful spine metastases, it is crucial that the current healthcare system is well-prepared for the increasing demand for spine SBRT.

- Il trattamento stereotassico ha dimostrato maggiore efficacia a lungo termine rispetto alla radioterapia convenzionale nella gestione del sintomo e nel garantire un maggiore controllo locale con minore necessità di re-irradiazione, con un profilo di tossicità sovrapponibile alla radioterapia convenzionale.
- Poche casistiche coinvolgono esclusivamente pazienti con malattia oligometastatica a livello vertebrale, con risultati comparabili ad esperienze relative ad altri distretti anatomici. Particolare attenzione alle istologie radioresistenti.
- Nella malattia con compressione midollare all'esordio, ad oggi studi retrospettivi hanno dimostrato maggiore efficacia con un ottimale profilo di sicurezza, seppur con dati prevalentemente nel setting post-operatorio.
- Nel caso di re-irradiazione, il trattamento stereotassico offre maggiore efficacia e può essere considerato nell'ottica di ridurre l'esposizione di strutture critiche a rischio.
- Necessaria comunque una attenta valutazione del paziente, ed il rispetto di requisiti clinici e tecnologici mandatori.

What is the overall pain response rate, complete pain response rate and duration of pain response after SBRT for painful vertebral metastases? How does pain response after SBRT compare to conventional palliative radiotherapy?

What is the local control (LC) after SBRT for spine metastases? What is the role of spine SBRT in oligo-metastatic disease (OMD)?

What is the practice of spinal SBRT to optimize safety and efficacy according to available evidence?

What is the toxicity profile of spine SBRT?

ESTRO practice guideline: Stereotactic Body Radiotherapy for Spine metastases

Authors (alphabetic order)

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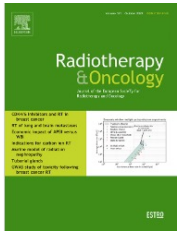
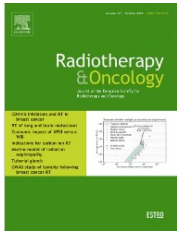


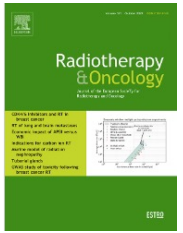
Accepted on Radiotherapy and Oncology

	KQ 1 Recommendations	Strength of Recommendation	Level of Evidence (Refs)
1.	For patients who are candidates to receive SBRT for painful vertebral metastases from solid malignancies, a baseline and post-SBRT pain assessment is recommended using either Brief Pain Inventory Index (BPI), Visual Analog Score (VAS) or Numeric Rating Scale (NRS).	Strong	High (13–18)
2.	For patients who are candidates to receive SBRT for painful vertebral metastases from solid malignancies, in the case of concurrent NSAID or opioid medications, a prophylactic dose increase is not recommended.	Strong	Expert opinion (13–18)
3.	For patients with painful vertebral metastases from solid malignancies, SBRT should be considered due to higher complete pain response rates in selected patients who are not frankly unstable (SINS greater than 12), who have no or minimal epidural disease (Bilsky 0-1), up to 3 contiguous vertebral segments in the radiation treatment volume and a prolonged life expectancy where durable local and control is also intended.	Strong	Moderate (13–18)

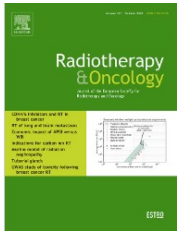
Abbreviations: KQ= key question; SBRT= stereotactic body radiotherapy; BPI= Brief Pain Inventory Index; VAS= Visual Analog Scale; NRS= Numeric Rating Scale; NSAID= non-steroidal anti-inflammatory drug; SINS= spinal instability neoplastic score



KQ 2 Recommendations	Strength of Recommendation	Level of Evidence (Refs)
1. For patients with vertebral metastases from solid malignancies, SBRT should be practiced with a prescription dose higher than the equivalent of 1x18Gy (BED_{10}=$50Gy_{10}$). For de novo spine metastases, high dose spine SBRT practice includes 1x20Gy, 1x24Gy, 2x12Gy, 3x10Gy, and 5x7Gy. Based on these schemes there is an expectation of local control (LC) ranging from 80-90% at 1-2 years.	Strong	Moderate/expert opinion (15,17,25–27)
2. For patients with painful vertebral metastases from solid malignancies meeting the eligibility criteria for spine SBRT, a fractionated approach using 2x12Gy is conditionally recommended as the preferred palliative SBRT dose and fractionation.	Conditional	Moderate (15)
3. For patients with vertebral metastases from solid malignancies, single fraction SBRT with 16 or 18Gy is not recommended as an alternative to conventional low-dose palliative radiotherapy (1x8Gy) if pain relief and/or quality of life are the primary treatment goals.	Strong	Moderate (17)
4. For patients with vertebral metastases from solid malignancies, where local therapy for OMD is supported by disease-specific guidelines and/or the tumor board, then spine SBRT is recommended for the majority of eligible patients. In selected patients, more aggressive combined modality approaches involving (separation) surgery and SBRT may be needed to optimize LC	Strong	Expert opinion/ moderate (19,25,28–32)



KQ 3 Recommendations	Strength of Recommendation	Level of Evidence (Refs)
1. Patients with vertebral metastases of solid malignancies treated with SBRT should be appropriately positioned in a reproducible supine position. Above the cervical-thoracic junction (e.g. above thoracic 4 vertebra), patient-specific rigid fixation is recommended (e.g. thermoplastic head and neck mask). Below the cervical-thoracic junction, near-rigid body immobilization, or no immobilization combined with intra-fraction positional verification/spine tracking, is recommended.	Strong	High (13,14,17,18,43)
2. For patients with vertebral metastases of solid malignancies treated with SBRT, target and organ-at-risk volumes should be delineated on a simulation CT with slice thickness ≤1.5mm, co-registered to T1 and T2 MRI series. Volumetric MRI images acquired in the radiotherapy treatment position are conditionally recommended.	Strong	High (13,14,17,18,43)
3. For patients with vertebral metastases of solid malignancies treated with SBRT, the overall geometric treatment uncertainty should allow a GTV/CTV to PTV margin smaller than 3 mm. A minimum PTV margin of 1 mm is recommended.	Strong	Moderate (14,18)
4. For patients with vertebral metastases of solid malignancies treated with SBRT, radiotherapy treatment should be performed using an intensity modulated delivery technique (i.e. fixed beam IMRT, VMAT, HT, robotic RT). The use of fast delivery techniques, such as using flattening filter free beams, is conditionally recommended.	Strong	High (13,14,17,18,43)



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