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Basic Original Report

Contemporary Practice Patterns for Palliative Radiation Therapy of Bone Metastases: Impact of a Quality Improvement Project on Extended Fractionation

Elizabeth M. Jaworski, MD, MS,[a] Huiying Yin, MS, MA,[a] Kent A. Griffith, MPH, MS,[b] Raveena Pandya, MS,[a] Brandon R. Mancini, MD,[c] Shruti Jolly, MD,[a] Thomas P. Boike, MD, MMM,[d] Jean M. Moran, PhD,[a] Michael M. Dominello, DO,[e] Melissa Wilson, MS,[f] Jan Parker, CMD,[g] Jay Burmeister, PhD,[e] Correen Fraser, BS, CMD,[h] Lynne Miller, RHIT,[i] Kaitlyn Baldwin, RN,[j] Melissa A. Mietzel, MS,[a] Margaret Grubb, MS,[a] Danielle Kendrick, BS, CPHQ,[a] Daniel E. Spratt, MD,[a] and James A. Hayman, MD, MBA[a,]* on behalf of the Michigan Radiation Oncology Quality Consortium

[a]Department of Radiation Oncology, University of Michigan, Ann Arbor, Michigan; [b]Department of Biostatistics, University of Michigan, Ann Arbor, Michigan; [c]Department of Radiation Oncology, West Michigan Cancer Center, Kalamazoo, Michigan; [d]Department of Radiation Oncology, MHP Radiation Oncology Institute/21st Century Oncology, Clarkston, Michigan; [e]Department of Radiation Oncology, Barbara Ann Karmanos Cancer Center, Wayne State University School of Medicine, Detroit, Michigan; [f]Department of Radiation Oncology, MHP Radiation Oncology Institute/21st Century Oncology, Troy, Michigan; [g]Department of Radiation Oncology, Henry Ford Allegiance, Jackson, Michigan; [h]Department of Radiation Oncology, Henry Ford Health System, Detroit, Michigan; [i]Department of Radiation Oncology, Sparrow Herbert-Herman Cancer Center, Lansing, Michigan; and [j]Department of Radiation Oncology, Munson Medical Center, Traverse City, Michigan

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Abstract

Purpose: Radiation therapy effectively palliates bone metastases, although variability exists in practice patterns. National recommendations advocate against using extended fractionation (EF) with courses greater than 10 fractions. We previously reported EF use of 14.8%. We analyzed practice patterns within a statewide quality consortium to assess EF use in a larger patient population after implementation of a quality measure focused on reducing EF.

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We are not authorized to share MROQC data. The data are individually owned by the member institutions of MROQC.

* Corresponding author: James A. Hayman MD, MBA; E-mail: hayman@med.umich.edu

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Methods and Materials: Patients treated for bone metastases within a statewide radiation oncology quality consortium were prospectively enrolled from March 2018 through October 2020. The EF quality metric was implemented March 1, 2018. Data on patient, physician, and facility characteristics; fractionation schedules; and treatment planning and delivery techniques were collected. Multivariable binary logistic regression was used to assess EF.

Results: Twenty-eight facilities enrolled 1445 consecutive patients treated with 1934 plans. The median number of treatment plans per facility was 52 (range, 7-307). Sixty different fractionation schedules were used. EF was delivered in 3.4% of plans. Initially, EF use was lower than expected and remained low over time. Significant predictors for EF use included complicated metastasis (odds ratio [OR], 2.04; 95% confidence interval [CI], 1.04-4.02; $P = .04$), lack of associated central nervous system or visceral disease (OR, 2.27; 95% CI, 1.2-4.2; $P = .01$), nonteaching versus teaching facilities (OR, 8.97; 95% CI, 2.1-38.5; $P < .01$), and treating physicians with more years in practice (OR, 12.82; 95% CI, 3.9-42.4; $P < .01$).

Conclusions: Within a large, prospective population-based data set, fractionation schedules for palliative radiation therapy of bone metastases remain highly variable. Resource-intensive treatments including EF persist, although EF use was low after implementation of a quality measure. Complicated metastases, lack of central nervous system or visceral disease, and treatment at nonteaching facilities or by physicians with more years in practice significantly predict use of EF. These results support ongoing efforts to more clearly understand and address barriers to high-value radiation approaches in the palliative setting.

Introduction

National guidelines recommend various effective dose and fractionation schemes for palliative radiation therapy (RT) of bone metastases, including single fraction regimens for select patients.[1-3] Advantages of shorter radiation courses include patient convenience, decreased toxicity, and shorter time to systemic therapy.[4] The American Society for Radiation Oncology's Choosing Wisely campaign specifically advocated against use of resource-intensive extended fractionation (EF) schemes with greater than 10 fractions.[5]

Prior efforts to characterize RT for bone metastases include institutional reports, nationwide Medicare Fee-For-Service and National Cancer Database analyses, and studies asking physicians to self-report hypothetical management strategies in a variety of clinical scenarios.[6-9] We previously reported on 1 such survey and found infrequent recommendation for EF (4.3%) and a minority of physicians (16.1%) recommending single fraction palliative RT.[10] These hypothetical scenario-based recommendations are in contrast to our 2017 analysis where we asked 20 institutions across our statewide radiation oncology quality consortium to report the details of the treatment plans for their 10 most recently treated cases.[11] In this latter series of real-world practice patterns, EF was used in 14.8% of plans, and single fraction use was 7.7%. After these initial reports, we launched a quality improvement project within our collaborative focusing on the treatment of bone metastases.

For our initial project we sought to lower the use of EF for bone metastases in our state-wide consortium. We hypothesized that EF use would decrease after adopting EF as a consortium-wide quality measure and providing feedback to our participating centers regarding patterns of its use. We also sought to investigate possible predictors of EF's use.

Methods and Materials

In this analysis, 28 facilities within the Michigan Radiation Oncology Quality Consortium (MROQC) prospectively enrolled, regardless of insurer, all patients with breast, lung, prostate, melanoma, or renal cell carcinoma receiving treatment for bone metastases between March 1, 2018, and October 31, 2020, into a web-based registry.[12] This project was an institutional review board−approved quality initiative using deidentified information for eligible patients. Clinical and demographic patient characteristics, treating facility and physician characteristics, and RT treatment plan details were collected. Treatment plans sometimes included more than 1 adjacent target.

Our quality measure was "percentage of patients who do not receive >10 fractions for treatment of bone metastases in accordance with the American Society for Radiation Oncology's Choosing Wisely guidelines" with full credit given for a rate >80%, partial credit given for a rate of 60% to 79%, and no credit for a rate <60%. This measure was a component of a facility-level pay-for-performance program, a facility-level prior authorization "gold card" program, which exempted the facility from participation in Blue Cross Blue Shield of Michigan's radiation oncology prior authorization program, and a physician-level value-based reimbursement program. The EF quality measure was included in the Gold Card Incentive Program measures from March 1, 2018 to November 1, 2019, and it was added as Pay-for-Performance Measure from January 1, 2019 to December 31, 2019. Real-time performance data were available to participating centers and were formally reported to all centers and discussed at in-person consortium meetings held every 4 months. To assess the evolution of EF use over time, we considered our 2017 convenience survey that reported 14.8% EF use as our baseline.[11] Of note, this initial 2017 survey retrospectively assessed palliative RT for bone metastases of the 10 most recently treated patients, and therefore was composed of a more heterogeneous population, including any primary cancer sites, whereas this project was restricted to the 5 primary sites listed previously. Funding for the consortium was provided by Blue Cross Blue Shield of Michigan and Blue Care Network and included staff support for data collection on eligible patients regardless of insurer. All authors are members of MROQC.

Covariable definitions

EF was defined as plans delivering >10 fractions. Time since initial diagnosis was analyzed as equal to or above versus below the median number of months since initial diagnosis. Our definition of "uncomplicated" bone metastasis, based on the definition of Cheon et al,[13] was a painful lesion without pathologic fracture or spinal cord or cauda equina compression or radicular pain, prior radiation to the site currently under treatment, prior surgery at the site, an associated soft tissue mass, or curative treatment intent. Retreatment included plans with direct overlap of a previously irradiated site. A teaching facility was defined as an institution training radiation oncology residents. The year the treating physician completed residency was defined according to quartiles. Metastatic burden was defined as oligometastatic for 1 to 5 total metastases versus greater than 5 total metastases.

Statistical analysis

Descriptive statistical methods were used to summarize patient, plan, facility, and physician characteristics. Multivariable odds ratios (ORs) and 95% confidence intervals (CIs) for the use of EF were calculated at the plan level using a logistic regression model. P values < .05 were considered significant. The data were analyzed using SAS Version 9.4 (SAS Institute, Cary, NC).

Results

During the study period, 1445 patients received palliative RT to bone metastases using 1934 plans at 28 different institutions. Characteristics of the patients, facilities, and treating physicians are listed in Table 1. Notably, these plans were most commonly administered to elderly patients with lung, breast, or prostate cancer with diminished performance status at time of treatment. Spine was the most frequently treated anatomic site (881/1934; 46%). Thirty one percent (595/1934) of plans treated uncomplicated bone metastases, 55% (1074/1934) targeted single bony lesions, and only 9% (172/1934) involved retreatment. Median time since diagnosis for the cohort was 21 months (range, 0-615 months). Seventy-five percent (1087/1445) of patients were treated with a single plan, whereas 18% (266/1445) and 6% (92/1445) received 2 and 3 or more plans, respectively.

As for facility characteristics, the median number of physicians practicing at participating facilities was 3, teaching facilities comprised 30%, and the median number of plans per facility was 52 (Table 1). At the physician level, the median number of plans was 14, with nearly equal numbers of physicians completing training 27 or more years ago, between 26 and 17 years ago, between 16 and 7 years ago, and 6 or fewer years ago (Table 1).

Sixty unique dose/fractionation schemes were delivered, with the most common being 30 Gy in 10 fractions (859/1934; 44%), 20 Gy in 5 fractions (368/1934; 19%), and 8 Gy in 1 fraction (227/1934; 12%) (Fig 1). EF was used in only 66 plans (3.4%). Fifteen centers used EF for 1% to 53% of their plans (Fig 2). Compared with our baseline rate in 2017 of 14.8%, after our adoption of EF as a quality measure on March 1, 2018, the use of EF within the remaining three-quarters of 2018 averaged approximately 5%, which was lower than expected. This rate remained low and continued to decline over time (P = .02) (Fig 3). Only 23% (439/1934) and 16% (313/1934) of plans were delivered with intensity modulated radiation therapy and stereotactic body radiation therapy, respectively.

Lastly, we investigated factors predicting EF use. Patients with complicated compared with uncomplicated bone metastases were more likely to receive EF (OR, 2.04; 95% CI, 1.04-4.02; P = .04), as were patients lacking associated central nervous system or visceral disease compared with those with it (OR, 2.27; 95% CI, 1.2-4.2; P = .01) (Fig 4). Likewise, patients treated at nonteaching compared with teaching facilities (OR, 8.97; 95% CI, 2.1-38.5; P < .01) and treatment by physicians with 17 or more years of practice were more likely to use EF plans (17-26 years: OR, 5.12; 95% CI, 1.5-18.1; P = .01; and ≥26 years: OR, 12.8; 95% CI, 3.9-42.4; P < .01). Additional factors that almost reached statistical significance included less than the median 21 months since diagnosis (OR, 1.89; 95% CI, 0.97-3.7; P = .06) and systemic therapy within the month before RT (OR, 1.74; 95% CI, 0.96-3.2; P = .07). Of note, total metastatic burden with more than 5 metastases compared with oligometastatic disease was not predictive of EF use (results not shown).

Discussion

This report confirms the variability of practice patterns for palliative RT and demonstrates the durable effect of quality metrics in altering these patterns in the treatment of bone metastases within a large, recently treated

Table 1 Clinical, facility, and physician characteristics

Clinical characteristics at plan level	All; n (%)*	Plans ≤ 10 fractions; n (%)*	Plans > 10 fractions (EF); n (%)*
n	1934	1868	66
Age (y), mean (SD) [range]	68 (12) [28.8-103.9]	68 (12) [28.8-103.9]	67 (12) [40.0- 93.5]
Sex			
Female	926 (48%)	891 (48%)	35 (53%)
Male	1008 (52%)	977 (52%)	31 (47%)
Race			
White	1599 (83%)	1543 (83%)	56 (85%)
Black	250 (13%)	241 (13%)	9 (14%)
Other/not reported	85 (4%)	84 (4%)	1 (2%)
KPS			
80-100	767 (40%)	741 (40%)	26 (39%)
50-70	843 (44%)	810 (43%)	33 (50%)
≤40	99 (5%)	99 (5%)	0
Not reported	225 (12%)	218 (12%)	7 (11%)
Primary cancer site[†]			
Non-small cell lung	615 (32%)	590 (32%)	25 (38%)
Breast	542 (28%)	521 (28%)	21 (32%)
Prostate	487 (25%)	477 (26%)	10 (15%)
Renal	171 (9%)	165 (9%)	6 (9%)
Small cell lung	71 (4%)	68 (4%)	3 (5%)
Melanoma	47 (2%)	46 (2%)	1 (2%)
Other/not reported	1 (0%)	1 (0%)	0
Anatomic site treated			
Spine	881 (46%)	854 (46%)	27 (41%)
Hip/pelvis	360 (19%)	349 (19%)	11 (17%)
Humerus/femur	253 (13%)	241 (13%)	12 (18%)
Rib	159 (8%)	151 (8%)	8 (12%)
Shoulder	97 (5%)	95 (5%)	2 (3%)
Skull	22 (1%)	21 (1%)	1 (2%)
Not reported	162 (8%)	157 (8%)	5 (8%)
Months since initial diagnosis, mean (SD) [range]	54 (76) [0-615.0]	54 (77) [0-615.0]	46 (65) [0.6-227.5]
Uncomplicated bone metastasis[‡]			
Yes	595 (31%)	580 (31%)	15 (23%)
No	1339 (69%)	1288 (69%)	51 (77%)
Retreatment			
Yes	172 (9%)	164 (9%)	8 (12%)
No	1762 (91%)	1704 (91%)	58 (88%)
Number of sites treated			
1	1074 (55%)	1033 (55%)	41 (62%)
2+	735 (38%)	714 (38%)	21 (32%)
Not reported	125 (6%)	121 (6%)	4 (6%)
Associated CNS or visceral disease			
Yes	893 (46%)	872 (47%)	21 (32%)
No	867 (45%)	829 (44%)	38 (58%)
Not reported	174 (9%)	167 (9%)	7 (11%)
Systemic therapy <4 weeks before RT			
Yes	970 (50%)	928 (50%)	42 (64%)
No	934 (48%)	912 (49%)	22 (33%)
Not reported	30 (2%)	28 (1%)	2 (3%)
Facility characteristics			
Teaching status			
Yes	587 (30%)	584 (31%)	3 (5%)
No	1347 (70%)	1284 (69%)	63 (95%)

(*Continued*)

Table 1 (*Continued*)

Clinical characteristics at plan level	All; n (%)*	Plans ≤ 10 fractions; n (%)*	Plans > 10 fractions (EF); n (%)*
Number of patients treated; median (range)	37 (7-205)	35 (7-205)	2 (1-8)
Number of plans treated; median (range)	52 (7-307)	50 (7-305)	4 (1-10)
Number of physicians; median (range)	3 (1-16)	3 (1-16)	2 (1-3)
Physician characteristics			
Year completed residency			
2014+	511 (26%)	506 (27%)	5 (8%)
2004-2013	425 (22%)	419 (22%)	6 (9%)
1994-2003	379 (20%)	365 (20%)	14 (21%)
≤1993	479 (25%)	442 (24%)	37 (56%)
Not reported	140 (7%)	136 (7%)	4 (6%)
Number of patients treated; median (range)	11 (1-65)	10 (1-64)	2 (1-8)
Number of plans treated; median (range)	14 (1-105)	13 (1-104)	2 (1-8)

Abbreviations: CNS = central nervous system; EF = extended fractionation; KPS = karnofsky performance status; RT = radiation therapy; SD = standard deviation.

* Owing to rounding, percent values may not equal 100.

† Additional histologies excluded from this quality initiative.

‡ Uncomplicated bone metastases lack the following: prior radiation or surgery at the currently treated site, spinal cord or cauda compression, radicular pain, an associated soft tissue mass, or curative treatment intent.

statewide cohort. For more than 2 years after the adoption of a quality measure focused on EF, we demonstrate infrequent use of EF in our consortium with an overall rate of 3.4%. We also identify factors predicting EF use, including complicated metastasis, lack of associated central nervous system or visceral disease, treatment at nonteaching facilities, and treating physicians with more years in practice. Additional factors including shorter time since diagnosis and having received the most recent dose of systemic therapy within 1 month before RT were suggestive of EF use but did not reach statistical significance.

We previously reported EF use of 14.8% in a convenience sample of 200 patients, which retrospectively analyzed palliative RT for the 10 most recently treated patients over a 2-month period and included bone metastases from any primary disease site.[11] In this updated prospective series, the consortium included 8 additional centers with a total of 1445 patients from 5 common primary sites treated over a more than 2-year period. After the implementation of EF as a quality measure, there was an immediate decline in the use of EF from 14.8% to an average of 5% within the first 9 months. In the rare cases of EF use, physician- and facility-specific factors appear to play as prominent a role

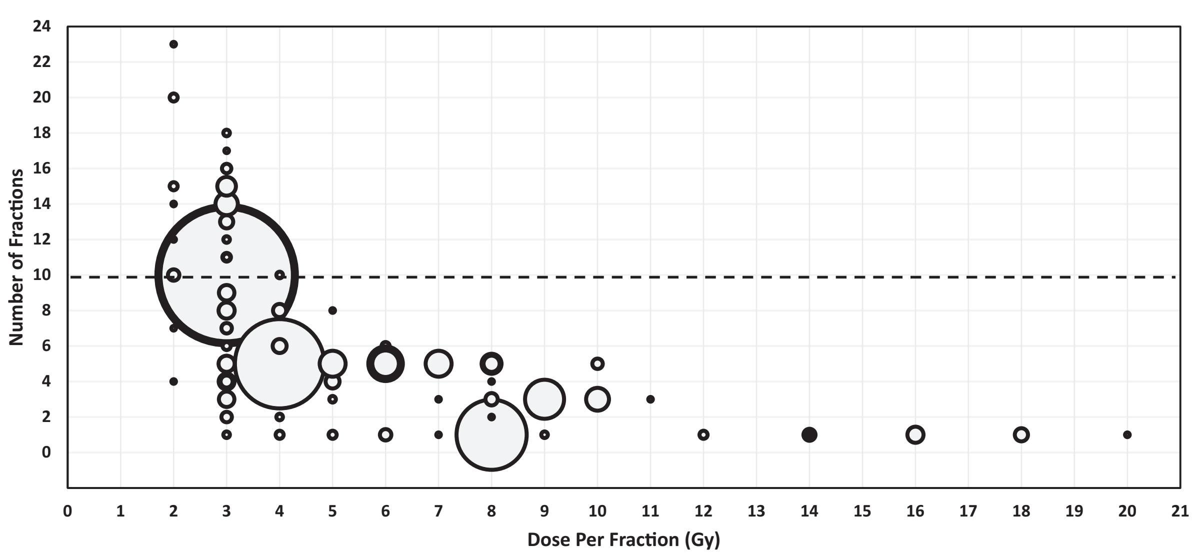

Fig. 1 Heterogeneity in fractionation by plan. Bubble plot of 1934 plans delivered using 60 different fractionation schemes. Circle size corresponds to the relative frequency of use for each fractionation scheme. Circles centered above the dashed line represent plans using extended fractionation.

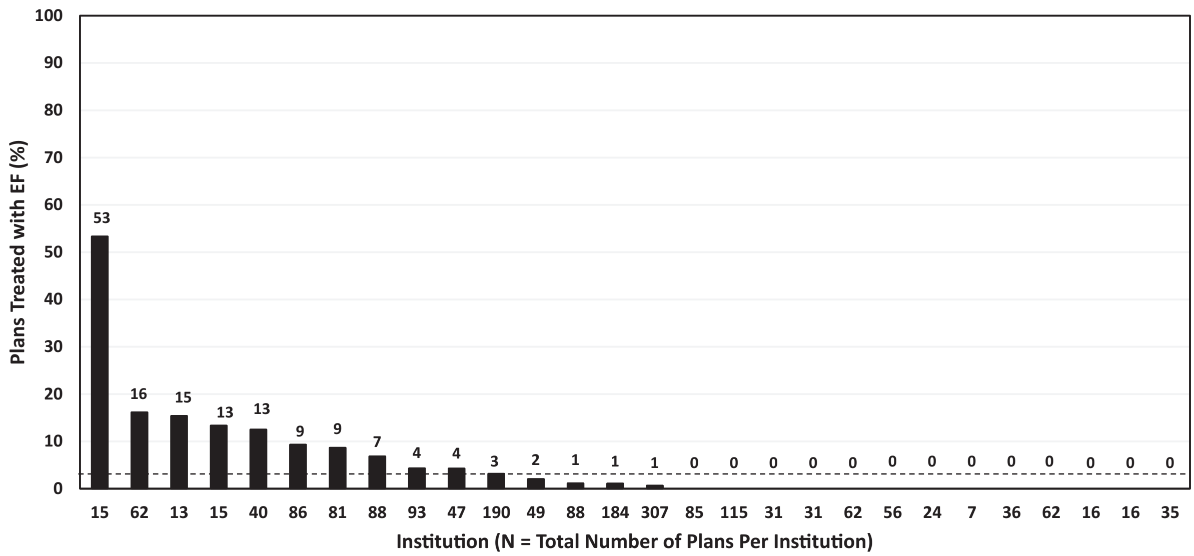

Fig. 2 Extended fractionation (EF) use by institution. Each bar represents 1 of 28 participating institutions. The number of plans treated per institution is listed along the x-axis. The percent of plans using EF is listed above each bar. Dashed line represents the overall rate of EF use (3.4%) within the consortium.

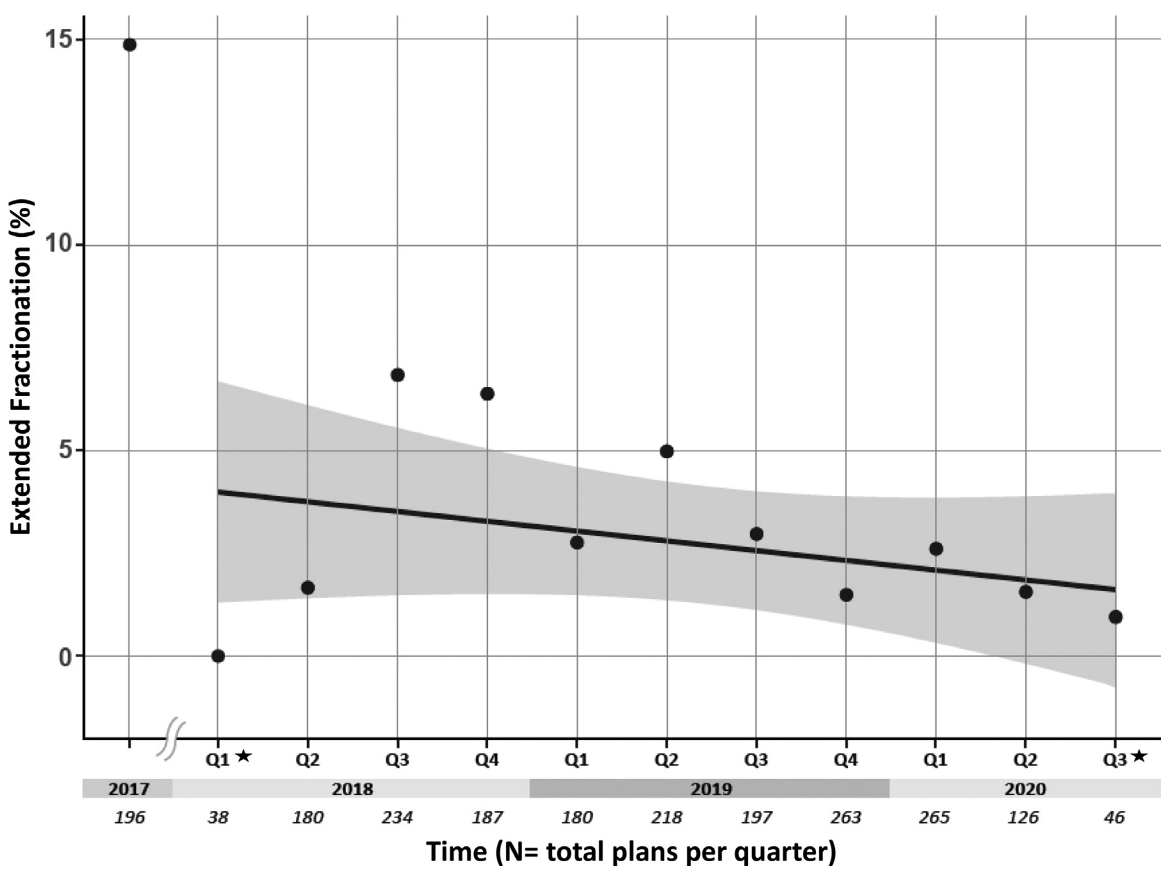

Fig. 3 Extended fractionation (EF) use over time. EF use in Q1 2017 derived from convenience sample point estimate previously reported by Spratt et al.[11] EF use from 2018 to 2020 derived from population-based samples of 28 facilities participating in current quality improvement project. X-axis shows time, with each year divided into quarters. Numerical values underneath each yearly quarter represent the number of total plans treated per quarter. Gray shading represents the 95% confidence interval for the regression trend line (black line). Regression line trend $P = .02$. *Indicates incomplete quarter with <3 months of data collection.

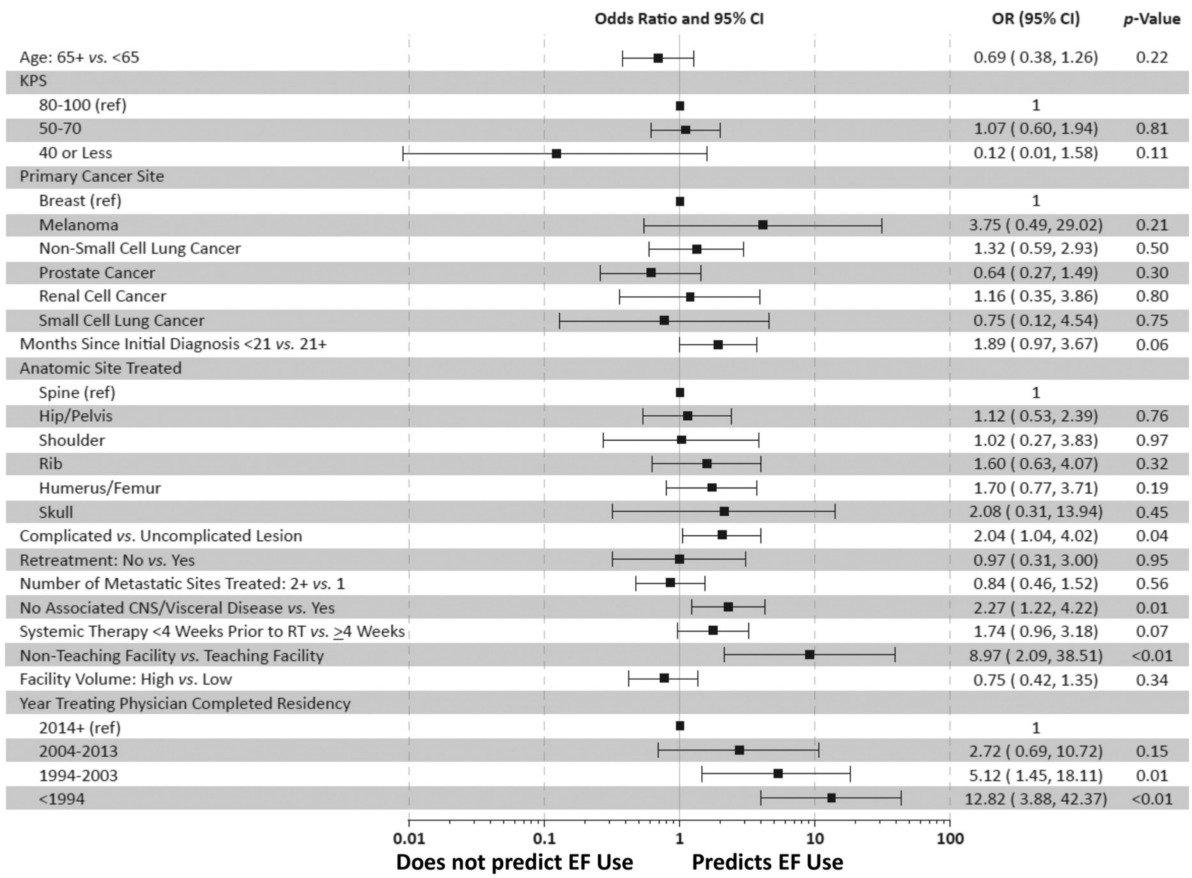

Fig. 4 Forest plot of factors predicting extended fractionation (EF) use. Multivariable binary logistic regression analysis of patient, facility, and treatment factors with odds ratio (OR) and 95% confidence interval (CI) given on logarithmic scale. OR < 1 does not predict EF use, whereas OR > 1 is predictive of EF use. Reference values are listed second or delineated as "(ref)." *Abbreviations:* CNS = central nervous system; KPS = karnofsky performance status; RT = radiation therapy.

as patient- or disease-specific factors. Given financial toxicity and costs associated with radiation, these results shed light on real-world implementable practices to affect practice patterns and cost-effectiveness of care.[14-16] A recent nationwide Medicare analysis demonstrated that between 2016 and 2018, 23.4% of patients treated for bone metastases received EF. They also found increasing years in practice predicts increased use of EF.[6] Using national data from the National Cancer Database, Wegner et al[7] recently reported that between 2010 and 2015 in patients with lung, breast, and prostate cancer the rate of EF decreased from 34% to 15%. Other groups have demonstrated use of EF ranging in frequency from 8% to 29.5%.[7,17-19] Our current results showing infrequent EF use in our Michigan consortium compare favorably with these previous reports. Possible explanations for our practice pattern are that active reporting of EF frequency and anonymous comparison with other consortium members along with programs tied to prior authorization exemption and increased physician reimbursement discourage EF use. Taken together, our contemporary real-world, clinical data demonstrate the effectiveness of a quality consortium to address resource intensive practice patterns and thereby improve quality of care.

The prospective, consecutively enrolled, population-based sample of diverse patients, facilities, and physicians is this study's strength. Furthermore, objective data about treatment planning details were collected for analysis. Limitations of the present investigation include that it is confined to select radiation oncology facilities in 1 Midwest state and did not include less common primary disease sites. In the future, we aim to focus other projects on more resource-intensive courses of palliative radiation for bone metastases, including lower than expected use of single fraction treatments and use of intensity modulated radiation therapy and/or stereotactic body radiation therapy. With the evolving role for RT in palliative treatment for bone metastases, our results support the ongoing collection and assessment of current practice patterns and focused quality improvement projects to improve care for all patients.

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References

1. Chow E, Zeng L, Salvo N, Dennis K, Tsao M, Lutz S. Update on the systematic review of palliative radiotherapy trials for bone metastases. *Clin Oncol (R Coll Radiol)*. 2012;24:112-124.
2. Chow E, Hoskin P, Mitera G, et al. Update of the international consensus on palliative radiotherapy endpoints for future clinical trials in bone metastases. *Int J Radiat Oncol Biol Phys*. 2012;82:1730-1737.
3. Lutz S, Balboni T, Jones J, et al. Palliative radiotherapy for bone metastases: An ASTRO evidence-based guideline. *Int J Radiat Oncol Biol Phys*. 2011;79:965-976.
4. Expert Panel On Radiation Oncology-Bone. ACR Appropriateness Criteria(R) non-spine bone metastases. *J Palliat Med*. 2012;15:521-526.
5. Choosing Wisely: American Society for Radiation Oncology. Available at: https://www.choosingwisely.org/clinician-lists/american-society-radiation-oncology-extended-fractionation-schemes-for-palliation-of-bone-metastases/. Accessed November 12, 2019.
6. Gupta A, Wang P, Sedhom R, et al. Physician practice variability in the use of extended-fraction radiation therapy for bone metastases: Are we choosing wisely? *JCO Oncol Pract*. 2020 JOP1900633.
7. Wegner RE, Matani H, Colonias A, Price F, Fuhrer R, Abel S. Trends in radiation fractionation for bone metastases: A contemporary nationwide analysis. *Pract Radiat Oncol*. 2020;10:402-408.
8. Logan JK, Jiang J, Shih Y-CT, et al. Trends in radiation for bone metastasis during a period of multiple national quality improvement initiatives. *J Oncol Pract*. 2019;15:e356-e368.
9. Ellsworth SG, Alcorn SR, Hales RK, McNutt RT, DeWeese TL, Smith TJ. Patterns of care among patients receiving radiation therapy for bone metastases at a large academic institution. *Int J Radiat Oncol Biol Phys*. 2014;89:1100-1105.
10. Gharzai LA, Beeler WH, Hayman JA, et al. Recommendations for Single-Fraction Radiation Therapy and Stereotactic Body Radiation Therapy in Palliative Treatment of Bone Metastases: A Statewide Practice Patterns Survey. *Pract Radiat Oncol*. 2019;9:e541-e548.
11. Spratt DE, Mancini BR, Hayman JA, et al. Contemporary Statewide Practice Pattern Assessment of the Palliative Treatment of Bone Metastasis. *Int J Radiat Oncol Biol Phys*. 2018;101:462-467.
12. Moran JM, Feng M, Benedetti LA, et al. Development of a model web-based system to support a statewide quality consortium in radiation oncology. *Pract Radiat Oncol*. 2017;7:e205-e213.
13. Cheon PM, Wong E, Thavarajah N, et al. A definition of "uncomplicated bone metastases" based on previous bone metastases radiation trials comparing single-fraction and multi-fraction radiation therapy. *J Bone Oncol*. 2015;4:13-17.
14. Yu JB, Pollack CE, Herrin J, et al. Persistent use of extended fractionation palliative radiotherapy for Medicare beneficiaries with metastatic breast cancer, 2011 to 2014. *Am J Clin Oncol*. 2019;42:493-499.
15. Palmer JD, Patel TT, Eldredge-Hindy H, et al. Patients undergoing radiation therapy are at risk of financial toxicity: A patient-based prospective survey study. *Int J Radiat Oncol Biol Phys*. 2018;101:299-305.
16. Hunter D, Mauldon E, Anderson N. Cost-containment in hypofractionated radiation therapy: A literature review. *J Med Radiat Sci*. 2018;65:148-157.
17. Ong WL, Foroudi F, Milne RL, Milar JL. Are we choosing wisely in radiation oncology practice-findings from an Australian population-based study. *Int J Radiat Oncol Biol Phys*. 2019;104:1012-1016.
18. Rutter CE, Yu JB, Wilson LD, Park HS. Assessment of national practice for palliative radiation therapy for bone metastases suggests marked underutilization of single-fraction regimens in the United States. *Int J Radiat Oncol Biol Phys*. 2015;91:548-555.
19. Lipitz-Snyderman A, Sima CS, Atoria CL, et al. Physician-driven variation in nonrecommended services among older adults diagnosed with cancer. *JAMA Intern Med*. 2016;176:1541-1548.