Original Investigation

Association of Early Imaging for Back Pain With Clinical Outcomes in Older Adults

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IMPORTANCE In contrast to the recommendations for younger adults, many guidelines allow for older adults with back pain to undergo imaging without waiting 4 to 6 weeks. However, early imaging may precipitate interventions that do not improve outcomes.

OBJECTIVE To compare function and pain at the 12-month follow-up visit among older adults who received early imaging with those who did not receive early imaging after a new primary care visit for back pain without radiculopathy.

DESIGN, SETTING, AND PARTICIPANTS Prospective cohort of 5239 patients 65 years or older with a new primary care visit for back pain (2011-2013) in 3 US health care systems. We matched controls 1:1 using propensity score matching of demographic and clinical characteristics, including diagnosis, pain severity, pain duration, functional status, and prior resource use.

EXPOSURES Diagnostic imaging (plain films, computed tomography [CT], magnetic resonance imaging [MRI]) of the lumbar or thoracic spine within 6 weeks of the index visit.

MAIN OUTCOME AND MEASURES Primary outcome: back or leg pain–related disability measured by the modified Roland-Morris Disability Questionnaire (score range, 0-24; higher scores indicate greater disability) 12 months after enrollment.

RESULTS Among the 5239 patients, 1174 had early radiographs and 349 had early MRI/CT. At 12 months, neither the early radiograph group nor the early MRI/CT group differed significantly from controls on the disability questionnaire. The mean score for patients who underwent early radiography was 8.54 vs 8.74 among the control group (difference, −0.10 [95% CI, −0.71 to 0.50]; mixed model, $P = .36$). The mean score for the early MRI/CT group was 9.81 vs 10.50 for the control group (difference,−0.51 [−1.62 to 0.60]; mixed model, $P = .18$).

CONCLUSIONS AND RELEVANCE Among older adults with a new primary care visit for back pain, early imaging was not associated with better 1-year outcomes. The value of early diagnostic imaging in older adults for back pain without radiculopathy is uncertain.

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When to image older adults with back pain remains controversial. Most guidelines regarding acute or chronic back pain focus on younger age groups. Many guidelines recommend that older adults undergo early imaging because of the higher prevalence of serious underlying conditions.[1-4] However, there is not strong evidence to support this recommendation.[5] A Cochrane review of back pain in older adults concluded that there was "under-representation of the older population in the back pain literature."[6] Adverse consequences of early imaging are more substantial in an older population because the prevalence of incidental findings on spine imaging increases with age.[7-11] Given the high prevalence of incidental findings in this age group, imaging older adults soon after initial presentation may lead to a cascade of subsequent interventions that increase costs without benefits. This phenomenon has been observed in workers' compensation populations.[12,13]

We used data from a prospective cohort of patients aged 65 years or older who presented to primary or urgent care for a new episode of care for *low back pain*, defined as no prior visits for low back pain within the previous 6 months, as part of the Back Pain Outcomes Using Longitudinal Data (BOLD) project.[14] We hypothesized that older adults who had lumbar spine imaging within 6 weeks of their index visit (early imaging), compared with those who did not, would have worse outcomes and greater health care use 1 year later.

Methods

Design Overview

We used a prospective observational cohort to compare, using propensity score matching of demographic and clinical characteristics, outcomes of patients who received vs those who did not receive early imaging.

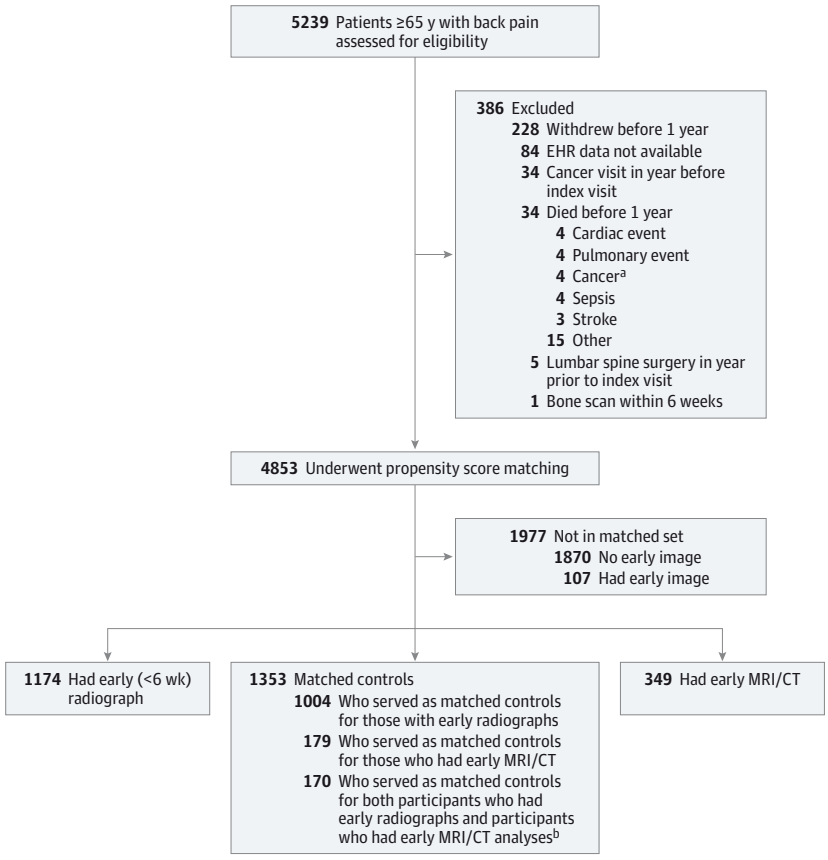
Setting and Participants

We previously described the BOLD cohort.[14,15] In brief, we prospectively enrolled 5239 patients 65 years or older initiating a new episode of care for back pain (**Figure**). We recruited patients presenting to primary or urgent care at 3 integrated health care systems: Harvard Vanguard, Henry Ford Health System, and Kaiser Permanente Northern California. The visit for back pain that qualified the patient for entry into the cohort was the index visit. We enrolled patients from March 2011 through March 2013 and categorized them by *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) codes as axial back pain alone, back and leg pain or herniated disk, lumbar spinal stenosis, and other (eTable 1 in the Supplement).

Patient-Reported Measures

At baseline, interviewers administered the patient-reported measures in person or by telephone within 3 weeks of a

Figure. Flow Diagram of Patients in the Back Pain Outcomes Using Longitudinal Data Study



EHR indicates electronic health record; MRI, magnetic resonance imaging; CT, computed tomography.

[a] Of the 4 patients who died with cancer: 1 had early imaging likely prompted by a red flag since the history on the imaging study indicated known cancer; 1 had early imaging (both plain films and computed tomography) that showed no evidence of cancer; 2 had no imaging at any time.

[b] Participants who had neither early radiographs nor early MRI/CT and were matched controls for comparisons.

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Table 1. Baseline Measures of Patients Who Underwent Radiographic Imaging vs Propensity to Matched Patients[a]

Variable	No. (%) of Patients		*P* Value[c]	Raw Difference Between Means (95% CI)[d]	Standardized Difference, %
	Matched Control (n = 1174)	Early Imaging (n = 1174)[b]			
Age, mean, (SD), y	74.3 (7.0)	74.3 (6.9)	.73	0.094 (−0.45 to 0.63)	1.35
Women	756 (64)	769 (66)	.57		−2.32
Study site					
Henry Ford	234 (20)	234 (20)	.99		0
Kaiser	809 (69)	809 (69)			
Harvard Vanguard	131 (11)	131 (11)			
Race					
Black	178 (15)	162 (14)	.77		1.67
Asian	56 (4.86)	51 (4.4)			
White	853 (73)	869 (75)			
Mixed race	77 (6.6)	78 (6.7)			
Hispanic ethnicity	65 (5.6)	72 (6.2)	.38		2.59
Education					
<High school	72 (6.2)	80 (6.8)	.92		−1.81
≥High school	648 (55)	647 (55)			
College graduate	249 (21)	245 (21)			
Graduate degree	202 (17)	199 (17)			
Living with spouse or partner	686 (59)	689 (59)	.80		0.83
Smoking status					
Never smoked	628 (57)	645 (55)	.73		−2.92
Quit >1 y ago	472 (40)	453 (39)			
Current	74 (6.3)	72 (6.2)			
Quan comorbidity score					
0	215 (18)	209 (18)	.82		−0.23
1	386 (33)	400 (34)			
>1	573 (49)	565 (48)			
Diagnosis					
Nonspecific back pain only	803 (68)	803 (68)			
Back and leg pain	274 (23)	276 (24)	.99		−0.53
Lumbar stenosis	26 (2.2)	27 (2.3)			
Other	71 (6.1)	68 (5.8)			
Pain duration					
<1 mo	417 (36)	430 (37)	.93		−0.25
1-3 mo	290 (25)	274 (23)			
3-6 mo	98 (8.4)	95 (8.1)			
6-12 mo	71 (6.1)	81 (6.9)			
1-5 y	139 (12)	139 (12)			
>5 y	157 (13)	155 (13)			
Confidence pain will improve in 3 mo					
0	216 (18)	201 (17)	.87		3.59
1-4	177 (15)	181 (15)			
5	197 (17)	187 (16)			
6-9	361 (31)	369 (32)			
10	221 (19)	233 (20)			

(continued)

patient's index visit. We collected information on demographics; duration of current episode of back or leg pain (<1 month, 1-3 months, 3-6 months, 6-12 months, 1-5 years, >5 years); and recovery expectations (confidence that their pain would be completely gone or much better in 3 months, on a scale from 0 "not at all confident" to 10 "extremely confident").

Our primary outcome was the Roland-Morris Disability Questionnaire (RMDQ),[16] a measure of physical limitations due to back pain (range, 0, no pain-related limitations, to 24, maximal pain-related limitations). We slightly modified this measure to indicate limitations due to back or leg pain (sciatica), which is a widely used modification.[16-18] The questionnaire contains 24 yes or no items. A minimal clinically important difference is 2 to 5 points.[17,19] We administered the following 6 secondary outcome measures at baseline and at 3, 6, and 12 months (primary end point): (1) a 0 to 10 numerical rating scale of average back pain intensity in the past week (0, no pain; 10, pain as bad as can be imag-

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Table 1. Baseline Measures of Patients Who Underwent Radiographic Imaging vs Propensity to Matched Patients[a] (continued)

Variable	No. (%) of Patients		*P* Value[c]	Raw Difference Between Means (95% CI)[d]	Standardized Difference, %
	Matched Control (n = 1174)	Early Imaging (n = 1174)[b]			
Prior imaging[e]	61 (5.2)	57 (4.9)	.69		−1.56
No. of days between index visit and interview, mean (SD)	15.4 (5.0)	15.4 (5.2)	.84	−0.038 (−0.41 to 0.34)	−0.75
RMDQ score, mean (SD)	10.3 (6.3)	10.5 (6.0)	.49	0.16 (−0.30 to 0.62)	2.60
BPI interference, mean (SD)	3.56 (2.5)	3.66 (2.4)	.27	0.11 (−0.082 to 0.29)	4.28
EuroQol 5D, mean (SD)					
Index	0.73 (0.18)	0.74 (0.17)	.84	0.0014 (−0.012 to 0.015)	0.64
VAS	73.7 (19)	72.7 (18)	.16	−1.07 (−2.54 to 0.41)	−5.47
PHQ-4 score			.93		0.37
Mean	1.72	1.73			
Median (range)	1.00 (0-12)	0 (0-12)		0.0086 (−0.19 to 0.21)	
NRS, mean (SD)					
Back pain	5.32 (2.7)	5.42 (2.7)	.38	0.090 (−0.11 to 0.29)	3.34
Leg pain	3.64 (3.3)	3.66 (3.3)	.85	−0.025 (−0.23 to 0.28)	0.74
≥1 Fall past 3 wk	85 (7.2)	109 (9.3)	.07	7.45	

Abbreviations: BPI, Brief Pain Inventory interference; EuroQol, health status measure; NRS, numerical rating scale; PHQ-4, 4-item Patient Health Questionnaire; RMDQ, Roland to Morris Disability Questionnaire; RVU, relative value unit; VAS, visual analog scale.

[a] Stratified first on site, and then performed logistic regression for propensity scores. Included in model are sex, race/ethnicity, age, educational achievement, smoking status, living with partner, Quan comorbidity score, baseline diagnosis, back pain duration, whether patient had imaging at that health care site in the year prior to index visit, baseline back pain intensity, baseline leg pain intensity, days between consent and interview, overall relative value units (RVUs) at the health care site in prior year, recovery expectations, and baseline RMDQ, EuroQol-5D index, PHQ-4 scores. For unmatched results of baseline measures, see eTable 5 in the Supplement. See the Methods section for definitions of pain and quality-of-life measures.

[b] The radiograph group could have received subsequent MRI/CT in days 0 to 42 (n = 138). Controls could not have received a radiograph in days 0 to 42.

[c] The McNemar or paired *t* tests were used to obtain *P* values.

[d] Raw difference between means were calculated only for continuous variables.

[e] Defined as spine imaging at the health care site in 365 days before the index visit.

ined); (2) a 0 to 10 numerical rating scale of average leg pain intensity in the past week; (3) the Brief Pain Inventory (BPI) interference scale, which represents the mean of 7 ratings of back pain interference with general activity; mood; and ability to walk, perform normal work, engage in relations with other people, sleep, and enjoy life (0, no pain interference; 10, maximum pain interference)[20,21]; (4) the Patient Health Questionnaire (PHQ-4), a 4-item screen for depression and anxiety (score range, 0-10; 0, no pain interference; 10, maximum pain interference) [22]; (5) the EuroQol health status measure (EuroQol 5D) consists of an index score that ranges from 0 (death) to 1 (perfect health) and reflects mobility, self-care, usual activities, pain and discomfort, and anxiety and depression and consists of a visual analog scale that ranges from 0 (the worst imaginable health state) to 100 (the best imaginable health state)[23]; and (6) a falls measure for which patients report the number of falls they experienced in the past 3 weeks and how many resulted in injury.[24]

Electronic Health Record Data

We used electronic health record (EHR) data to calculate relative value units (RVUs),[25-27] assess resource use, and estimate Quan comorbidity scores,[28] a weighted score derived from the Charlson comorbidity index[29] based on 12 comorbidities. The Quan score and prior year RVUs were used in propensity matching. We obtained patient data 365 days before and after the index visit or until a patient either withdrew or died. The data included *Current Procedural Terminology* (*CPT*) codes for each procedure and filled prescription data. One site used *ICD-9-CM* procedure codes rather than *CPT* codes, so we converted *ICD-9-CM* procedure codes to the closest corresponding *CPT* codes. We captured *CPT* and *ICD-9-CM* codes for clinic visits, hospitalizations, and imaging tests. We did not account for medications. We linked *CPT* codes to year-specific RVUs, without including geographic modifiers. For applying costs to resource use, we used the Marketscan data warehouse to obtain 2012 payer and patient reimbursement amounts for *CPT*-based procedures and medications.[30] Remaining outcomes were post hoc and exploratory.

Using data from the 12 months before the index visit, we calculated the Quan comorbidity score.[28] To avoid altering the association between early imaging and RVUs, we summed all RVUs beginning with the day after the image (or the analogous day for the matched controls) until 365 days after the index visit for each individual. We performed similar summations for back pain-related RVUs (spine-related RVUs[31]; see eTable 1 in the Supplement for codes used), summarized as RVUs for physical therapy, injection therapy, imaging, and surgery.

If *CPT* codes were ambiguously spine-related, we only counted procedures as spine-related if they took place on the same date as unambiguous spine-related *CPT* codes. We classified all procedures on the index date as spine-related. Additionally, because 1 site used generic codes rather than *CPT* codes for all physical therapy encounters, we imputed RVUs at this site using year-appropriate RVUs for physical therapy from the other 2 sites. We included all procedures. For minor procedures, we imputed a year-appropriate 5-minute evaluation and management RVU (*CPT* code 99211).

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Table 2. Baseline Measures of Patients Who Underwent Magnetic Resonance Imaging or Computed Tomography Early vs Propensity-Matched Patients[a]

Variable	No. (%) of Patients		*P* Value[c]	Raw Difference Between Means (95% CI)[d]	Standardized Difference, %
	Matched Control (n = 349)	Early Imaging (n = 349)[b]			
Age, mean, (SD), y	73.2 (6.6)	72.8 (6.0)	.37	−0.42 (−1.34 to 0.49)	−6.63
Women	228 (65)	229 (66)	.94		−0.60
Study site					
Henry Ford	70 (20)	70 (20)	.99		0
Kaiser	215 (62)	215 (62)			
Harvard Vanguard	64 (18)	64 (18)			
Race					
Black	65 (19)	62 (18)	.91		5.35
Asian	10 (2.9)	11 (3.2)			
White	252 (73)	254 (73)			
Mixed race	17 (4.9)	21 (6.0)			
Hispanic ethnicity	20 (5.8)	17 (4.9)	.59		−3.84
Education					
<High school	29 (8.3)	26 (7.5)	.95		2.01
≥High school	181 (52)	183 (53)			
College graduate	85 (24)	81 (23)			
Graduate degree	54 (15)	57 (16)			
Living with spouse or partner	214 (61)	215 (62)	.80		1.32
Smoking status					
Never smoked	182 (52)	192 (55)	.52		−8.04
Quit >1 y ago	138 (40)	134 (39)			
Current	28 (8.1)	21 (6.1)			
Quan comorbidity score					
0	58 (17)	44 (13)	.23		4.75
1	114 (33)	130 (37)			
>1	177 (51)	175 (50)			
Diagnosis					
Nonspecific back pain only	176 (50)	174 (50)	.91		2.30
Back and leg pain	136 (39)	137 (39)			
Lumbar stenosis	29 (8.3)	27 (7.7)			
Other	8 (2.3)	11 (3.2)			
Pain duration					
<1 mo	85 (24)	90 (26)	.93		−5.57
1-3 mo	80 (23)	84 (24)			
3-6 mo	30 (8.6)	29 (8.3)			
6-12 mo	28 (8.0)	31 (8.9)			
1-5 y	60 (17)	50 (14)			
>5 y	66 (19)	64 (18)			
Confidence pain will improve in 3 mo					
0	67 (19)	54 (16)	.62		12.30
1-4	65 (19)	60 (17)			
5	73 (21)	73 (21)			
6-9	85 (24)	92 (27)			
10	58 (17)	68 (20)			

(continued)

We used natural language processing to help identify early imaging studies that reported cancer (see eText in the Supplement). We also examined the proportion of patients in each group diagnosed after the imaging date (or matched date for controls) with a serious condition that could be detected by spine imaging (cancer, spine infections, spine fractures, cauda equina compression). If patients in the early imaging group were more likely to be diagnosed with these conditions, it would raise the question of whether clinicians were missing these diagnoses in patients who did not receive early imaging.

Early Imaging Group

Based on existing guidelines,[32] we defined patients who underwent lumbar spine imaging within 6 weeks of their index visit as having received early imaging. Although guidelines differ in the exact length of time recommended to wait prior to

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Table 2. Baseline Measures of Patients Who Underwent Magnetic Resonance Imaging or Computed Tomography Early vs Propensity-Matched Patients[a] (continued)

Variable	No. (%) of Patients		*P* Value[c]	Raw Difference Between Means (95% CI)[d]	Standardized Difference, %
	Matched Control (n = 349)	Early Imaging (n = 349)[b]			
Prior imaging[e]	48 (14)	49 (14)	.92		0.83
No. of days between index visit and interview, mean (SD)	14.4 (5.4)	14.8 (5.3)	.29	0.39 (−0.33 to 1.12)	7.35
RMDQ score, mean (SD)	12.5 (6.3)	12.4 (5.8)	.76	−0.12 (−0.86 to 0.63)	−1.94
BPI interference, mean (SD)	4.34 (2.5)	4.47 (2.4)	.43	0.13 (−0.19 to 0.45)	5.28
EuroQol 5D, mean (SD)					
Index	0.67 (0.20)	0.69 (0.18)	.14	0.019 (−0.0062 to 0.045)	10.24
VAS	69.1 (20)	70.5 (18)	.38	1.29 (−1.59 to 4.18)	7.22
PHQ-4			.91		−0.81
Mean	2.14	2.12			
Median (range)	1.0 (0-12)	1.0 (0-12)		−0.023 (−0.44 to 0.39)	
NRS, mean (SD)					
Back pain	5.94 (2.7)	5.89 (2.7)	.80	−0.049 (−0.43 to 0.33)	−1.79
Leg pain	5.13 (3.3)	5.00 (3.2)	.53	−0.13 (−0.55 to 0.28)	−4.03
≥1 Fall past 3 wk	32 (9.2)	30 (8.6)	.80	−1.92	

Abbreviations: BPI, Brief Pain Inventory interference; EuroQol, health status measure; NRS, numerical rating scale; PHQ-4, 4-item Patient Health Questionnaire; RMDQ, Roland to Morris Disability Questionnaire; RVU, relative value unit; VAS, visual analog scale.

[a] Stratified first on site, and then performed logistic regression for propensity scores. See Table 1 footnotes for a list of characteristics included in the model. See the Methods section for definitions of pain and quality-of-life measures.

[b] The MRI/CT group could have received same day or subsequent radiograph in days 0 to 42 (n = 37). Controls could not have received a radiograph in days 0 to 42.

[c] The McNemar or paired *t* tests were used to obtain *P* values

[d] Raw difference between means calculated only for continuous variables.

[e] Defined as spine imaging at the health care site in 365 days before the index visit.

imaging, 6 weeks is used by a variety of organizations[33-35] and was the consensus optimal approach in 1 study.[36] We defined 2 separate early imaging cohorts: (1) patients undergoing early plain film imaging (radiographs) and (2) patients undergoing early advanced imaging (magnetic resonance imaging [MRI] or computed tomography [CT]) (see eTable 2 in the Supplement). We assigned patients who had multiple imaging procedures within the first 6 weeks to the radiograph or advanced imaging group based on their first study. Some patients assigned to the early radiograph group could also have received early MRI/CT, but only if the imaging occurred after their radiograph. Patients who had radiographs and an MRI/CT on the same day were assigned to the advanced imaging group.

Nonearly or No Imaging Controls

We propensity-matched patients who underwent early imaging with a BOLD cohort patient who did not have any spine imaging within 6 weeks of the index visit. We constructed a propensity score as the logit function of the probability of receiving early imaging for a patient with specific characteristics or prognostic factors.[37]

Because the patient sample characteristics differed across study sites,[15] we stratified the propensity score matching algorithm by site. All regressions included sex; self-assessed race/ethnicity; age; educational, smoking, and marital status; Quan comorbidity score; baseline diagnosis category (axial back pain alone, back and leg pain or herniated disk, lumbar spinal stenosis, and other); back pain duration; receipt of spine imaging in the year prior to index visit; days between index visit and interview; total RVUs in prior year; baseline back pain intensity; leg pain intensity; Roland-Morris Disability Questionnaire, EuroQol 5D, and PHQ-4 scores; and recovery expectations. We separately matched patients receiving early radiographs or early MRI/CT to the closest control using a greedy algorithm, which finds the closest match of nonimaged to imaged patients without replacement until no further matches can be identified.[38] Nonimaged patients could serve as controls in both the early radiograph and the early MRI/CT analyses. After matching at each site, we combined data from all 3 sites for further analysis.

The study was approved by the institutional review boards (IRBs) of all the participating institutions. We obtained written or verbal consent from all patients with a waiver of documentation of consent having been granted by the IRBs.

Statistical Analysis

We report summary descriptive statistics for the early radiograph and early MRI/CT groups. We used the McNemar tests for categorical variables and paired *t* tests for continuous variables to compare at baseline patients who received early imaging with matched patients who did not receive early imaging. We also calculated standardized differences between the matched groups for all variables. Finally, we used linear mixed-effects models to obtain adjusted differences between those who received early imaging and those who did not on total RVUs, spine-specific RVUs (further subdivided into those for physical therapy, injection therapy, imaging, and surgery), patient-reported outcome measures at 3, 6, and 12 months, and reimbursement estimates. Each model was adjusted for sex, age, baseline back or leg pain diagnosis

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Table 3. Three-, 6-, and 12- Month Outcomes of Early Radiograph vs Matched Control[a]

	Radiograph		Radiograph vs None		Mixed Model	
	Matched Control (n = 1174)	Early Imaging (n = 1174)	Raw Difference Between Means (95% CI)	Standardized Difference, %	Estimate (95% CI)[b]	*P* Value
RMDQ, Mean (SD), mo						
3	9.54 (6.64)	9.54 (6.41)	0.062 (−0.50 to 0.63)	−0.08	−0.02 (−0.46 to 0.42)	.93
6	9.06 (6.88)	8.92 (6.57)	−0.012 (−0.62 to 0.60)	−2.05	−0.10 (−0.55 to 0.35)	.66
12	8.74 (6.95)	8.54 (6.56)	−0.10 (−0.71 to 0.50)	−3.00	−0.21 (−0.66 to 0.34)	.36
BPI Interference, Mean (SD), mo						
3	2.99 (2.50)	2.99 (2.37)	0.025 (−0.19 to 0.24)	−0.32	−0.007 (−0.18 to 0.16)	.94
6	2.87 (2.52)	2.73 (2.35)	−0.092 (3.29 to 3.61)	−5.75	−0.12 (−0.29 to 0.05)	.17
12	2.83 (2.53)	2.72 (2.42)	−0.071 (−0.29 to 0.15)	−4.33	−0.11 (−0.28 to 0.06)	.21
EuroQol 5D Index, Mean (SD), mo						
3	0.76 (0.18)	0.76 (0.17)	−0.0022 (−0.018 to 0.013)	0.70	0.001 (−0.011 to 0.014)	.86
6	0.76 (0.18)	0.77 (0.17)	0.0016 (−0.014 to 0.018)	1.62	0.001 (−0.012 to 0.013)	.88
12	0.77 (0.18)	0.78 (0.17)	0.0048 (−0.011 to 0.021)	3.97	0.007 (−0.005 to 0.02)	.26
EuroQol 5D VAS, Mean (SD), mo						
3	71.9 (19.2)	72.3 (18.1)	0.39 (−1.25 to 2.02)	1.84	0.34 (−1.04 to 1.72)	.62
6	73.1 (18.1)	72.5 (18.3)	−0.96 (−2.64 to 0.72)	−3.60	−0.71 (−2.12 to 0.70)	.32
12	72.7 (18.8)	73.2 (18.6)	0.29 (−1.42 to 2.01)	2.60	0.46 (−0.94 to 1.86)	.52
PHQ-4						
3 mo						
Mean	1.84	1.80	−0.0021 (−0.23 to 0.22)	−1.45	−0.04 (−0.23 to 0.15)	.67
Median (range)	1.0 (0 to 12)	1.0 (0 to 12)				
6 mo						
Mean	1.82	1.77	−0.0090 (−0.25 to 0.23)	−1.79	−0.06 (−0.25 to 0.14)	.58
Median (range)	0 (0 to 12)	1.0 (0 to 12)				
12 mo						
Mean	1.85	1.80	−0.062 (−0.29 to 0.17)	−2.07	−0.07 (−0.26 to 0.13)	.50
Median (range)	1.0 (0 to 12)	0 (0 to 12)				
Back Pain NRS, Mean (SD), mo						
3	3.87 (2.73)	3.83 (2.60)	0.0010 (−0.23 to 0.23)	−1.65	−0.05 (−0.24 to 0.14)	.61
6	3.78 (2.73)	3.62 (2.61)	−0.097 (−0.34 to 0.15)	−6.03	−0.14 (−0.33 to 0.05)	.15
12	3.71 (2.73)	3.55 (2.62)	−0.12 (−0.36 to 0.12)	−5.77	−0.14 (−0.34 to 0.05)	.14
Leg Pain NRS, Mean (SD), mo						
3	3.23 (2.95)	2.96 (2.88)	−0.30 (−0.56 to −0.042)	−9.43	−0.31 (−0.52 to −0.09)	.006
6	3.12 (2.90)	2.82(2.78)	−0.25 (−0.52 to 0.013)	−10.7	−0.30 (−0.52 to −0.08)	.009
12	3.06 (2.93)	2.83 (2.77)	−0.23 (−0.48 to 0.024)	−8.34	−0.26 (−0.48 to −0.04)	.021

Abbreviations: BPI, Brief Pain Inventory Interference; EuroQol, health status measure; NRS, numerical rating scale; PHQ-4, Patient Health Questionnaire; RMDQ, Roland-Morris Disability Questionnaire; RVU, relative value unit; VAS, EuroQuol Group visual analog scale.

[a] See the Methods section for definitions of pain and quality-of-life measures

[b] Adjusted for sex, age, diagnosis (axial back pain only, back and leg, spinal stenosis or other), back pain duration and total RVUs in the year prior to the index visit.

category, baseline back pain duration, and RVUs in the 12 months before the index visit. We used Bonferroni-corrected significance thresholds (2-sided α of .05/3 = .017) for some exploratory comparisons (overall RVUs, spine-specific RVUs, and back pain intensity) for each 12-month analysis.

Given the sample sizes in the early radiograph (n = 1174) and early MRI/CT (n = 349) groups, the study had more than 90% power to detect small between-group differences in Roland-Morris Disability Questionnaire score (radiograph, 1-point difference; MRI/CT, 2-point difference), overall RVUs (radiograph, 18-RVU difference; MRI/CT, 11-RVU difference), and spine-specific RVUs (radiograph, 60-RVU difference; MRI/CT, 45-RVU difference). Power calculations were post hoc.

We performed all analyses using SAS statistical software version 9.3 (SAS Institute Inc).

Results

Of the 5239 participants, we excluded 84 patients for whom EHR data were not available, 228 patients who withdrew before completing 1 year of follow-up, 34 who had a cancer

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Table 4. Three-, 6-, and 12-Month Magnetic Resonance Imaging or Computed Tomographic Outcomes vs Matched Control[a]

	MRI/CT		MRI/CT vs None		Mixed Model	
	Matched Control (n = 349)	Early Imaging (n = 349)	Raw Difference Between Means (95% CI)	Standardized Difference, %	Estimate (95% CI)[b]	*P* Value
RMDQ, Mean (SD), mo						
3	11.5 (6.82)	11.6 (6.51)	−0.23 (−1.25 to 0.80)	0.40	0.12 (−0.65 to 0.89)	.76
6	11.2 (7.13)	10.5 (6.66)	−0.83 (−1.91 to 0.25)	−9.81	−0.57 (−1.35 to 0.21)	.15
12	10.5 (7.20)	9.81 (6.99)	−0.51 (−1.62 to 0.60)	−9.68	−0.53 (−1.30 to 0.24)	.18
BPI, Mean (SD), mo						
3	3.70 (2.57)	3.68 (2.58)	−0.13 (−0.54 to 0.27)	−0.57	−0.01 (−0.34 to 0.31)	.93
6	3.69 (2.72)	3.39 (2.67)	−0.34 (−0.78 to 0.10)	−11.1	−0.26 (−0.59 to 0.06)	.11
12	3.46 (2.66)	3.36 (2.66)	−0.085 (−0.50 to 0.33)	−3.78	−0.07 (−0.40 to 0.25)	.67
EuroQuol 5D Index, Mean (SD), mo						
3	0.71 (0.20)	0.72 (0.19)	0.012 (−0.019 to 0.043)	5.15	0.007 (−0.02 to 0.03)	.58
6	0.71 (0.21)	0.72 (0.19)	0.014 (−0.019 to 0.046)	5.15	0.005 (−0.02 to 0.03)	.69
12	0.72 (0.20)	0.74 (0.19)	−0.020 (−0.011 to 0.051)	10.3	0.01 (−0.01 to 0.04)	.28
EuroQual 5D VAS, Mean (SD), mo						
3	67.6 (20.4)	69.1 (19.5)	1.81 (−1.44 to 5.07)	7.82	1.17 (−1.47 to 3.81)	.38
6	69.0 (17.8)	70.1 (19.4)	1.17 (−2.05 to 4.39)	5.66	0.77 (−1.90 to 3.43)	.57
12	67.3 (19.4)	71.6 (19.3)	4.04 (0.92 to 7.15)	22.3	3.88 (1.21 to 6.54)	.004
PHQ-4						
3 mo						
Mean	2.37	2.31	−0.15 (−0.65 to 0.35)	−1.92	−0.05 (−0.45 to 0.34)	.79
Median (range)	1 (0 to 12)	1 (0 to 12)				
6 mo						
Mean	2.32	2.19	−0.17 (−0.66 to 0.32)	−4.36	−0.09 (−0.49 to 0.30)	.64
Median (range)	1 (0 to 12)	1 (0 to 12)				
12 mo						
Mean	2.31	2.12	−0.21 (−0.65 to 0.23)	−6.68	−0.16 (−0.55 to 0.24)	.44
Median (range)	1 (0 to 12)	1 (0 to 12)				
Back Pain NRS, Mean (SD), mo						
3	4.52 (2.84)	4.24 (2.78)	−0.37 (−0.82 to 0.075)	−9.99	−0.27 (−0.62 to 0.09)	.14
6	4.50 (2.83)	4.11 (2.82)	−0.39 (−0.84 to 0.060)	−13.8	−0.33 (−0.69 to 0.03)	.07
12	4.22 (2.83)	4.01 (2.76)	−0.11 (−0.56 to 0.34)	−7.59	−0.13 (−0.49 to 0.22)	.47
Leg Pain NRS, Mean (SD), mo						
3	4.12 (3.07)	3.77 (2.96)	−0.47 (−0.94 to 0.0086)	−11.4	−0.34 (−0.75 to 0.07)	.10
6	4.18 (3.08)	3.58 (3.05)	−0.58 (1.07 to −0.089)	−19.4	−0.56 (−0.97 to −0.14)	.008
12	4.00 (3.04)	3.77 (3.06)	−0.20 (−0.69 to 0.28)	−7.74	−0.19 (−0.60 to 0.22)	.36

Abbreviations: BPI, Brief Pain Inventory Interference; EuroQol, health status measure; NRS, numerical rating scale; PHQ-4, 4-item Patient Health Questionnaire; RMDQ, Roland-Morris Disability Questionnaire; RVU, relative value unit; VAS, visual analog scale.

[a] See the Methods section for definitions of pain and quality-of-life measures.

[b] Adjusted for sex, age, diagnosis (nonspecific, back and leg, or other), back pain duration, and total RVUs in the year prior to the index visit.

diagnosis in the year prior to the index visit, 34 who died, 5 who had lumbar spine surgery in the year prior to the index visit, and 1 patient who had a bone scan and no other imaging within 6 weeks after the index visit (Figure). Of the 1264 patients (26%) who received early radiographs, 1174 were matched, and of the 366 patients (7.5%) who received early MRI/CT, 349 were matched. The baseline characteristics of the propensity-matched participants who underwent early diagnostics did not differ statistically or clinically from those who did not (**Table 1** and **Table 2**).

Table 3 summarizes the 3-, 6-, and 12-month patient-reported outcome measures. Twelve-month cumulative RVUs in the early radiograph and their matched controls are available in eTable 3 in the Supplement. **Table 4** and eTable 4 in the Supplement show analogous data for the early MRI/CT group and their matched controls. Follow-up rates of patient-reported outcome measures ranged from 88% to 91% across groups and time points. There was neither a statistically significant nor clinically meaningful difference in the primary outcome, the Roland-Morris Disability Questionnaire, between the early and not early imaging groups at any time point (eg, 3-month no early radiograph vs early radiograph, mixed-model difference −0.02 [95% CI, −0.46 to 0.42]). Patient-reported outcomes were not different between the groups except for leg pain numerical rating scale scores. Patients receiving early radiography had lower numerical scores at months 3 (mean difference, 0.31), 6 (mean differ-

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Table 5. Subsequent Serious Diagnoses in Early Imaging Groups Matched Controls

Diagnosis	Imaging, No. (%) [95% CI]		*P* Value[a]
	Matched Contol	Early Imaging	
Matched Control vs Early Radiography (n = 1174 per group)			
Cancer diagnosis	26 (2.2) [1.5 to 3.2]	20 (1.7) [1.1 to 2.6]	.37
Inflammatory spondyloarthropathies	2 (0.2) [0.05 to 0.6]	6 (0.5) [0.2 to 1.1]	.16
Fractures of spine	7 (0.6) [0.3 to 1.2]	23 (2.0) [1.3 to 2.9]	.004
Osteomyelitis, No.	0	0	
Matched Control vs Early MRI/CT (n = 349 per group)			
Cancer diagnosis	7 (2.0) [0.1 to 4.1]	7 (2.0) [0.1 to 4.1]	.99
Inflammatory spondyloarthropathies	1 (0.3) [0.01 to 1.6]	4 (1.2) [0.5 to 2.9]	.18
Fractures of spine	0	3 (0.9) [0.3 to 2.5]	
Osteomyelitis, No.	0	0	

Abbreviations: CT, computed tomography; MRI, magnetic resonance imaging.

[a] McNemar test used to obtain *P* values.

ence, 0.30), and 12 (mean difference, 0.26) for leg pain than did those who did not receive early imaging. Although statistically significant, these differences were clinically unimportant. The 12-month differences between early radiograph patients and controls for other secondary outcomes were extremely small and not statistically significant: −0.071 (95% CI, −0.29 to 0.15) for BPI; 0.29 (95% CI, −1.42 to 2.01) for the EuroQol 5D visual analog scale; and −0.062 (95% CI, −0.29 to 0.17) for PHQ-4. Patients with early MRI/CT vs controls had statistically significant but not clinically meaningful differences on 2 measures: the early MRI/CT group had lower 6-month leg pain numerical rating scale scores (difference, −0.58 [95% CI, −1.07 to −0.089]) and higher 12-month EuroQol 5D-visual analog scale scores (difference, 4.04 [95% CI, 0.92 to 7.15]).

In contrast, there were marked differences in 1-year resource use and costs. Mean total RVUs were approximately 40% higher ($P < .001$) in the early radiograph and 50% higher ($P = .01$) in the early MRI/CT group than in the no early imaging or no imaging groups, and overall costs were 27% ($P < .001$) and 30% ($P < .04$) higher, respectively. Estimated monetary differences in 1-year total payments (payer and patient contributions) were $1380 higher (95% CI, $692 to $2060), for patients with early radiographs and $1430 higher (95% CI, $36.8 to $2820) for patients with early MRI/CTs (eTable 3 and eTable 4 in the Supplement). Early imaging cohorts incurred significantly greater mean RVUs, overall expenditures, and spine-related expenditures in most utilization categories. Spine-related, *CPT*-based expenditures as a percentage of overall expenditures were 17% in the early radiograph vs 7% for the no early or no radiograph group, and 29% for the early MRI/CT vs 11% for the no early or no MRI/CT group.

We did not observe differences in proportions of patients with cancer diagnoses in the next year among patients receiving early imaging vs controls (**Table 5**). Among patients who underwent early imaging, only 1 of 1630 (0.06%) had cancer (lymphoma) diagnosed on the early imaging study (lymphadenopathy seen on MRI). In contrast, patients who underwent imaging diagnostics early had more fractures detected (2% in the early radiograph group vs 0.6% in the no early or no radiograph group; 0.9% in the early MRI/CT group vs 0% in the no early or no MRI/CT group).

Discussion

Our study demonstrates that older adults who had spine imaging within 6 weeks of a new primary care visit for back pain had pain and disability over the following year that was not different from matched patients who did not undergo early imaging. Patients receiving early imaging had small, clinically unimportant improvement in leg pain intensity and EuroQol 5D scores. We had hypothesized that patients undergoing early imaging would have worse outcomes, due to incidental findings leading to unnecessary and potentially harmful interventions. This was not the case. However, patients who had early imaging had substantially higher resource use and reimbursement expenditures than did matched controls, as reflected by greater RVUs, overall costs, and spine-specific costs. Overall, spine-specific, spine injection, and spine imaging RVUs and associated payer and patient expenditures were all greater in the early imaging groups than in the no early or no imaging groups.

Approximately 90% of older adults have incidental findings on spine imaging.[11] These findings can lead to adverse labeling as well as unnecessary interventions with associated morbidity.[39] Most guidelines exclude older patients from imaging restrictions. Prior studies suggested an association between early imaging and subsequent interventions[13,40] and our results are concordant with a recent study of injured workers.[41]

Despite the lack of evidence supporting routine imaging for older adults with back pain, guidelines commonly recommend that older patients with back pain undergo imaging. Chou and colleagues[1,42] recommended considering plain radiography for patients older than 50 years. The American College of Radiology's guidelines state that early imaging with MRI is appropriate for patients older than 70 years and may be appropriate for patients older than 50 years with osteoporosis.[32] The European guidelines for nonspecific low back pain classify patients older than 55 years as being in the red flag category for justifying imaging.[43] Our study results support an alternative position that regardless of age, early imaging should not be performed routinely.

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Because the rationale for undergoing early imaging is to avoid missing infrequent but serious diagnoses (cancer, infection, etc), we examined the proportion in each group that subsequently received these diagnoses over the ensuing year. We found that the proportion of cancer diagnoses was similar for both groups. Our data suggest that absence of early imaging is not associated with a higher incidence of missed cancer diagnoses. Only 1 case of cancer (lymphoma) was detected by early imaging, and this was not located in the spine but rather in adjacent adenopathy.

Our study has limitations. First, there is the potential for confounding by indication; ie, patients receiving early imaging had worse prognoses than patients not getting early imaging. We tried to minimize confounding through propensity matching. However, residual confounding of unmeasured attributes could exist. Confounding by health care site could also exist, since patient characteristics varied by site,[15] as did patterns of care. Therefore, we adjusted for site in each analysis. Second, our data on pain duration is limited by the overlap of the pain duration categories. Third, our baseline measures were administered up to 3 weeks after the index visit and thus could reflect responses to therapy since the index visit. We assumed that all index-day procedures were related to the patient's back pain, but patients' index visits may have been for multiple problems, thus leading us to overattribute index-day procedures to back pain. Fourth, patients who are more likely to ask for early imaging might also be more likely to use resources subsequently. We attempted to control for this phenomenon by propensity matching for prior year RVUs and also controlled for prior year RVUs in our data analyses. Fifth, we assessed *CPT*-based and medication use but were not able to capture out-of-system use or indirect costs.

Conclusions

Among older adults with a new primary care visit for back pain, early imaging was not associated with better 1-year outcomes.

ARTICLE INFORMATION

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Author Contributions: Dr Jarvik and Mr Comstock had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.
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