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The Utilization and Downstream Associations of MRI for Lateral Epicondylitis

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Abstract

Purpose: Low-value imaging is associated with wasteful healthcare spending and patient harm. The routine use of magnetic resonance imaging (MRI) for the work up of lateral epicondylitis is an example of low-value imaging. As such, our aim was to investigate the utilization of MRIs ordered for lateral epicondylitis, the characteristics of those receiving an MRI, and the downstream associations of MRI with other care.

Methods: We identified patients ≥18 years with a diagnosis of lateral epicondylitis between 2010–2019 using a Humana claims database. We identified patients with a Current Procedural Terminology code corresponding to an elbow MRI. We analyzed utilization and downstream treatment cascades in those undergoing MRI. Multivariable logistic regression models were utilized to assess the odds of receiving an MRI, adjusting for age, sex, insurance type, and comorbidity index. Separate multivariable logistic regression analyses were used to determine the association between receiving an MRI and the incidence of secondary outcomes (e.g. receiving surgery).

Results: A total of 624,102 patients met the inclusion criteria. Of 8,209 (1.3%) patients receiving an MRI, 3,584 (44%) received it within 90 days after diagnosis. There was notable regional variation in MRI use. MRIs were most frequently ordered by primary care specialties and for younger, female, commercially ensured and more comorbid patients. Receiving an MRI was associated with an increase in downstream treatments, including surgery [OR 9.58 (9.12–10.07)], injection [OR 2.90 (2.77–3.04)], therapy [OR 1.81 (1.72–1.91)], and cost ($134 per patient).

Conclusions: While there is variation in the use of MRI for lateral epicondylitis and its use is associated with downstream effects, the routine use of MRI for the diagnosis of lateral epicondylitis is low. In an era of value-based care, the minimal utilization of low-value imaging is commendable and methods to achieve such minimization of low-value imaging should be investigated and applied to other low-value interventions (e.g. electrodiagnostic studies for carpal tunnel syndrome).

Clinical Relevance: The routine use of MRI for lateral epicondylitis is low. Understanding interventions to minimize such low-value care in lateral epicondylitis can be utilized to inform improvement efforts to minimize low-value care for other conditions.

INTRODUCTION:

Minimizing care that provides little benefit has become an important goal as patients and policy makers both seek to minimize unnecessary interventions, or low-value care. Low-value care accounts for an estimated 25%−30% of total healthcare expenditures in the United States (US)[1,2]. From the patient perspective, low-value care may lead to unnecessary financial burden and trigger unwarranted care cascades that introduce patients to risk/harm without improving the care delivered. For example, an unnecessary MRI may uncover an incidental finding that is unsettling (psychological harm) and lead to further unnecessary work-up. Such tests and treatments may cause financial and iatrogenic harm[3]. Low-value imaging has been a central focus of low-value care initiatives. For example, Choosing Wisely, a United States-based campaign, was launched in 2012 by the American Board of Internal Medicine as an initiative to target unnecessary usage of healthcare[4–6]. Choosing Wisely campaigns include limiting magnetic resonance imaging (MRI) for nonspecific low back pain and avoiding advanced imaging studies for most pediatric musculoskeletal conditions prior to a complete workup[4–6]. In the field of hand and upper extremity surgery, a growing body of literature suggests that electrodiagnostic studies may represent a low-value test in the routine work up of carpal tunnel syndrome[7–10].

MRI use for enthesopathy of the extensor carpi radialis brevis or lateral epicondylitis may represent another area of low-value testing. Lateral epicondylitis is mucoid degeneration of the common extensor tendon in the middle of an average human adult lifespan (ages 35–60)[11]. It causes variable pain intensity, functional limitation, and care utilization. Lateral epicondylitis is primarily a clinical diagnosis based upon clinical history and physical exam. Radiography, ultrasound, and MRI may be used for diagnosis, prognostication, or to rule out other causes of elbow pain. However, MRI is expensive, and the literature varies with regard to its ability to provide information valuable to patient care. MR findings representative of lateral epicondylitis have been demonstrated by Mackay et al to be present in 100% of those with symptomatic elbows, but also present in 11–35% of these subjects' contralateral, asymptomatic elbows[12,13]. Walton et al demonstrated that MR imaging findings do not correlate with symptoms[14]. With the raised cost, high false-positive rate, and debatable addition of diagnostic information, the routine use of MRI for the diagnosis of lateral epicondylitis is an example of low-value imaging.

As such, the purpose of this study was to 1) investigate the utilization of MRIs ordered for a clinical diagnosis of lateral epicondylitis, 2) the characteristics associated with MRIs ordered, and 3) the downstream associations of MRI on future care for lateral epicondylitis.

METHODS:

We conducted a retrospective study using a Humana patient claims database (PearlDiver Technologies, Colorado Springs, CO, USA). This database contains patient-level claims records from over 91 million beneficiaries from a large, national insurer between 2010 and 2019. We identified patients 18 years and older with a diagnosis of lateral epicondylitis using International Classification of Diseases Ninth or Tenth Revision (ICD-9 or 10) codes (Table 1). We required patients to be 1) continuously enrolled six months before and after their first and last lateral epicondylitis-associated claim, respectively, and 2) only queried records (MRI and clinical visits) with lateral epicondylitis in the primary diagnosis field. We only included private, Medicare Advantage, and Medicaid managed care plans. The database does not contain medical claims from workers' compensation plans nor does it contain data to address provider-level variation. We only included patients with complete demographic data. We then identified all such patients with a Current Procedural Terminology (CPT) code corresponding to elbow MRI (Table 1). A flow diagram of cohort creation is shown in Figure 1. We further identified the subgroup of patients who received an elbow MRI for lateral epicondylitis within 90 days after initial diagnosis. For secondary analysis (to understand the association between MRI use and downstream treatment cascades – utilization and insurer reimbursement), we also identified all patients who underwent surgery, steroid injections, or physical or occupational therapy (PT/OT) for lateral epicondylitis using their respective CPT codes (Table 1) paired with the lateral epicondylitis diagnostic code. The prevalence of these outcomes was compared between patients who received an MRI and those who did not. Categorical data, including age range, sex, region, and insurance type, were analyzed using chi-square tests between groups. Elixhauser comorbidity index (ECI) scores were compared using the Mann-Whitney test. Multivariable logistic regression models were constructed to assess the primary outcome, defined as the odds of receiving an MRI, adjusting for age, sex, insurance type, and ECI. Separate multivariable logistic regression analyses were used to determine the association between receiving an MRI and the incidence of secondary outcomes (receiving surgery, steroid injection, or PT/OT use). The full cohort (those receiving an MRI and those who did not) was included in these regression models. To obtain the additional total insurer reimbursement for patients who received an MRI compared to those who did not, we performed a multivariable linear regression using the presence of an MRI claim for lateral epicondylitis (binary) as an independent variable while adjusting for age, sex, insurance type (commercial insurance, Medicare Advantage, or Managed Medicaid), and ECI.

RESULTS:

Overall, 624,102 patients with a primary diagnosis of lateral epicondylitis met inclusion criteria and 8,209 (1.3%) received an elbow MRI for lateral epicondylitis during their treatment. Of the initial claims for lateral epicondylitis, a plurality [213,432 (34.2%)] were from primary care specialties (internal medicine, geriatrics, family practice, general practice), 189,987 (30.4%) were from orthopaedic or hand surgery specialists, and 118,162 (18.9%) were from other specialties. The remainder of claims had no documented specialty. Demographic information for the MRI and no MRI cohorts are shown in Table 2. Of the patients who received an elbow MRI for lateral epicondylitis, 3,584 (43.7%) received it within 90 days after initial diagnosis. Trends in use of MRI for lateral epicondylitis by year in this database are shown in Figure 2. When patients were divided into cohorts by mean time from diagnosis to MRI, patients who had a time from diagnosis to MRI greater than the mean time of 300 days had a rate of subsequent surgery of 817/2,348 (34.8%) compared to 1,509/5,861 (25.7%) in patients with a time from diagnosis to MRI of less than 300 days ($p<0.001$).

In multivariable logistic regression analysis, a regional effect was demonstrated. Patients in the West region had the lowest odds of receiving an MRI (adjusted OR = 0.81 [0.75 – 0.88]) and patients in the Northeast region had the greatest odds of receiving an MRI (adjusted OR = 1.12 [1.05–1.19]). We then characterized the overall and region-specific incidence of various treatment modalities for patients who did and did not receive an MRI (Table 3), showing a markedly increased unadjusted incidence of surgery in patients who received an MRI. After adjusting for age, sex, insurance type, region, and ECI, patients who received an MRI had an OR of 9.58 [9.12 – 10.07] of undergoing surgery. Similarly, patients in the MRI cohort had an adjusted OR of 2.90 [2.77–3.04] and 1.81 [1.72–1.91] for receiving a steroid injection or PT/OT, respectively. The full regression model output for each of these outcomes is provided in Appendix Tables S1–S4.

Mean costs for MRI and various treatment modalities are shown in Table 4. A regression model showed that receiving an MRI increased the total lateral epicondylitis-related reimbursement by $134 per patient after adjusting for differences attributable to age, sex, insurance type, and ECI. Region- and insurance type-specific time intervals from initial diagnosis to MRI are shown in Table 5.

DISCUSSION:

In this study, we took a step-wise approach to assess the use of MRI for lateral epicondylitis. We demonstrate that although there is variation in the utilization of MRI for lateral epicondylitis and that its use is associated with downstream interventions and cost, the use of MRI for the diagnosis of lateral epicondylitis is low. As the healthcare system continues to evolve to emphasize high-value care, the low utilization of MRI for the diagnosis of lateral epicondylitis is noteworthy and may serve as an example that can be further evaluated and applied to other low-value interventions that are used more routinely.

Variation in care that is not driven by patient or clinical factors, and is not supported by a strong evidence base to guide decision-making, is a common starting point for identifying low-value care (unwarranted variation). For example, prior research has demonstrated that clinician-level factors result in variation in care. Patients treated for a distal radius fracture by a hand surgeon had a greater odds of undergoing internal fixation than if treated by a non-hand surgery trained orthopaedic surgeon.[15] While patient-level variation may be warranted, unwarranted variation in care, such as care discordant with best available evidence or guidelines, can inform quality improvement efforts. Notably, although our study identifies variation in care at the aggregate level (e.g. region) we are unable to analyze variation at the physician or practice level. Other drivers of unwarranted variation in care have been suggested (e.g. reimbursement models or financial ownership[16–18]), that we were unable to account for given the study methodology. Further, while we noted variation in the use of MRI for lateral epicondylitis, this rate of utilization was low.

The Choosing Wisely Campaign is an initiative aimed at helping patients and clinicians chose care that is evidence-based, necessary, and of high-value.[19] Launched in 2012, Choosing Wisely has produced more than 600 recommendations for ways to align medical care with clinical value and reduce low-value services.[20] Despite participation from more than 80 medical specialist organizations and widespread publicity, the campaign has yet to have a significant impact, demonstrating the difficulty in implementing change for low-value care.[21] Although the general trend of MRI ordering associated with a diagnosis of lateral epicondylitis has risen minimally over time (Figure 1), the low rate of its utilization is commendable. Given the difficulty in disincentivizing low-value care, the low utilization of MRI for lateral epicondylitis may be used as an example to understand clinician behavior. For example, perhaps the dissemination approach (e.g., timing, mechanism, avenues) of evidence discouraging MRI use for lateral epicondylitis has helped keep MRI utilization low, or physicians are potentially more comfortable with the clinical exam and making a clinical diagnosis. Qualitative studies and further investigation into clinical practices, knowledge, and incentives, may elucidate the reasons for continually low MRI use and these results may inform interventions to decrease the use of other low-value interventions.

Also important to note is that, while we aim to reduce unnecessary, variable, and low-value MRI use for the diagnosis of lateral epicondylitis, utilization need not be zero. For example, baseline MRI utilization due to factors like ruling out concomitant or other pathology (e.g. posterolateral rotator instability) may in fact be warranted and may change a diagnosis. Further, the notion that patients who received an MRI >300 days after diagnosis were more likely to undergo surgery than those who received an MRI within 300 days after diagnosis perhaps suggests that some patients may have received an MRI to confirm a diagnosis after failed non-operative treatment. Simultaneously, the reimbursement associated with obtaining an MRI was relatively low. Although we cannot make conclusions regarding the value (quality/cost) of the MRI, if it was in fact utilized for ruling out concomitant pathology or changing a diagnosis, this cost may be warranted. It is also feasible that those receiving an MRI had fewer office or emergency department visits. Despite recognizing the downstream effects associated with MRI use, this does not imply that these treatments (e.g. surgery, PT/OT) are unwarranted. For example, PT/OT is a mainstay of treatment and thus its use may be cost-effective. As we were unable to evaluate physician level details, the increased use of MRI and subsequent treatments (e.g. injections) may be related to physician level characteristics as opposed to the MRI itself.

We recognize limitations to each portion of this investigation. Regarding variation, there are limitations inherent to large national database studies (e.g. reliance on coding accuracy, inability to control for variation in coding practices) that have been well documented[22,23]. For example, there may have been patients with lateral epicondylitis that were diagnosed with “elbow pain” who were not captured in this cohort. We also cannot extract further detail about the ordering provider, nor detail about why the study was ordered, which may be useful information in directing educational resources and quality improvement initiatives. Future studies may include evaluating the association of regional variation with the number of MRI scanners or the rate of litigation or malpractice claims because these variables may lead to variation in utilization. We were unable to adjust the reimbursements reported for regional differences in cost of living, which may be a potential driver of the geographic variations discovered. We also cannot conclude that an MRI and/or its findings directly lead to surgery and the subsequent treatment cascade (e.g. perhaps a patient was already scheduled for surgery and the MRI was ordered for pre-operative planning or prognostication). Regardless, the need for an MRI in this scenario is debatable. The drivers of MRI use in patients who have failed non-operative treatment warrant further study. The drivers of such orders (e.g. practice model, further detail on provider sub-specialty, failure of non-operative treatment) can be identified through future work and inform de-implementation efforts.

This work demonstrates that while there is variation in the utilization of MR imaging for the treatment of a clinical diagnosis of lateral epicondylitis, its use is low. As increasing efforts are being directed toward reducing low value care, understanding methods by which to minimize such care can be investigated and applied to other areas where minimization of low value care is needed.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

References:

1. Berwick DM, Hackbarth AD. Eliminating waste in US health care. JAMA. 2012;307(14):1513–1516. doi:10.1001/jama.2012.362 [PubMed: 22419800]
2. Shrank WH, Rogstad TL, Parekh N. Waste in the US Health Care System: Estimated Costs and Potential for Savings. JAMA. 2019;322(15):1501–1509. doi:10.1001/jama.2019.13978 [PubMed: 31589283]
3. Mertz K, Eppler SL, Thomas K, et al. The Association of Financial Distress With Disability in Orthopaedic Surgery. J Am Acad Orthop Surg. 2019;27(11):e522–e528. doi:10.5435/JAAOS-D-18-00252 [PubMed: 31125323]
4. Wisely Choosing. Imaging Tests for Lower-Back Pain. Accessed September 20, 2021. https://www.choosingwisely.org/patient-resources/imaging-tests-for-back-pain/
5. Wisely Choosing. American College of Radiology. Ten Things Physicians and Patients Should Question. Accessed September 20, 2021. https://www.choosingwisely.org/societies/american-college-of-radiology/
6. Wisely Choosing. American Academy of Pediatrics – Section on Orthopaedics and the Pediatric Orthopaedic Society of North America. Accessed September 20, 2021. https://www.choosingwisely.org/clinician-lists/aap-posna-mri-or-ct-for-musculoskeletal-conditions-in-children/
7. Billig JI, Sears ED. Utilization of Diagnostic Testing for Carpal Tunnel Syndrome: A Survey of the American Society for Surgery of the Hand. J Hand Surg Am. 2022;47(1):11–18. doi:10.1016/j.jhsa.2021.09.037 [PubMed: 34991798]
8. Becker SJE, Makanji HS, Ring D. Changes in treatment plan for carpal tunnel syndrome based on electrodiagnostic test results. J Hand Surg Eur Vol. 2014;39(2):187–193. doi:10.1177/1753193413497903 [PubMed: 23906785]
9. American Academy of Orthopaedic Surgeons. Management of Carpal Tunnel Syndrome Evidence-Based Clinical Practice Guideline. Accessed February 25, 2022. https://www.aaos.org/quality/qualityprograms/upper-extremity-programs/carpal-tunnel-syndrome/.
10. Graham B. The value added by electrodiagnostic testing in the diagnosis of carpal tunnel syndrome. J Bone Joint Surg Am. 2008;90(12):2587–2593. doi:10.2106/JBJS.G.01362 [PubMed: 19047703]
11. Faro F, Wolf JM. Lateral epicondylitis: review and current concepts. J Hand Surg Am. 2007;32(8):1271–1279. doi:10.1016/j.jhsa.2007.07.019 [PubMed: 17923315]
12. Mackay D, Rangan A, Hide G, Hughes T, Latimer J. The objective diagnosis of early tennis elbow by magnetic resonance imaging. Occup Med (Lond). 2003;53(5):309–312. [PubMed: 12890829]

13. van Leeuwen WF, Janssen SJ, Ring D, Chen N. Incidental magnetic resonance imaging signal changes in the extensor carpi radialis brevis origin are more common with age. J Shoulder Elbow Surg. 2016;25(7):1175–1181. doi:10.1016/j.jse.2016.01.033 [PubMed: 27068386]
14. Walton MJ, Mackie K, Fallon M, et al. The reliability and validity of magnetic resonance imaging in the assessment of chronic lateral epicondylitis. J Hand Surg Am. 2011;36(3):475–479. doi:10.1016/j.jhsa.2010.11.040 [PubMed: 21334144]
15. Chung KC, Shauver MJ, Yin H, Kim HM, Baser O, Birkmeyer JD. Variations in the use of internal fixation for distal radial fracture in the United States medicare population. J Bone Joint Surg Am. 2011;93(23):2154–2162. doi:10.2106/JBJS.J.012802 [PubMed: 22159850]
16. Segal JB, Sen AP, Glanzberg-Krainin E, Hutfless S. Factors Associated With Overuse of Health Care Within US Health Systems: A Cross-sectional Analysis of Medicare Beneficiaries From 2016 to 2018. JAMA Health Forum. 2022;3(1):e214543-e214543. doi:10.1001/jamahealthforum.2021.4543
17. Young GJ, Zepeda ED, Flaherty S, Thai N. Hospital Employment Of Physicians In Massachusetts Is Associated With Inappropriate Diagnostic Imaging. Health Affairs. 2021;40(5):710–718. doi:10.1377/hlthaff.2020.01183 [PubMed: 33939515]
18. Whaley CM, Zhao X, Richards M, Damberg CL. Higher Medicare Spending On Imaging And Lab Services After Primary Care Physician Group Vertical Integration. Health Affairs. 2021;40(5):702–709. doi:10.1377/hlthaff.2020.01006 [PubMed: 33939518]
19. Born K, Kool T, Levinson W. Reducing overuse in healthcare: advancing Choosing Wisely. BMJ. 2019;367:l6317. doi:10.1136/bmj.l6317 [PubMed: 31690578]
20. Cliff BQ, Avanceña ALV, Hirth RA, Lee SYD. The Impact of Choosing Wisely Interventions on Low-Value Medical Services: A Systematic Review. Milbank Q. 2021;99(4):1024–1058. doi:10.1111/1468-0009.12531 [PubMed: 34402553]
21. Patashnik EM, Dowling CM. Realizing The Promise Of Choosing Wisely Will Require Changes Both In The Culture Of Specialty Societies And In Public Policy. Health Affairs Forefront. doi:10.1377/forefront.20171107.649027
22. Pugely AJ, Martin CT, Harwood J, Ong KL, Bozic KJ, Callaghan JJ. Database and Registry Research in Orthopaedic Surgery: Part I: Claims-Based Data. J Bone Joint Surg Am. 2015;97(15):1278–1287. doi:10.2106/JBJS.N.01260 [PubMed: 26246263]
23. Xiao M, Donahue J, Safran MR, Sherman SL, Abrams GD. Administrative Databases Used for Sports Medicine Research Demonstrate Significant Differences in Underlying Patient Demographics and Resulting Surgical Trends. Arthroscopy. Published online September 20, 2020. doi:10.1016/j.arthro.2020.09.013

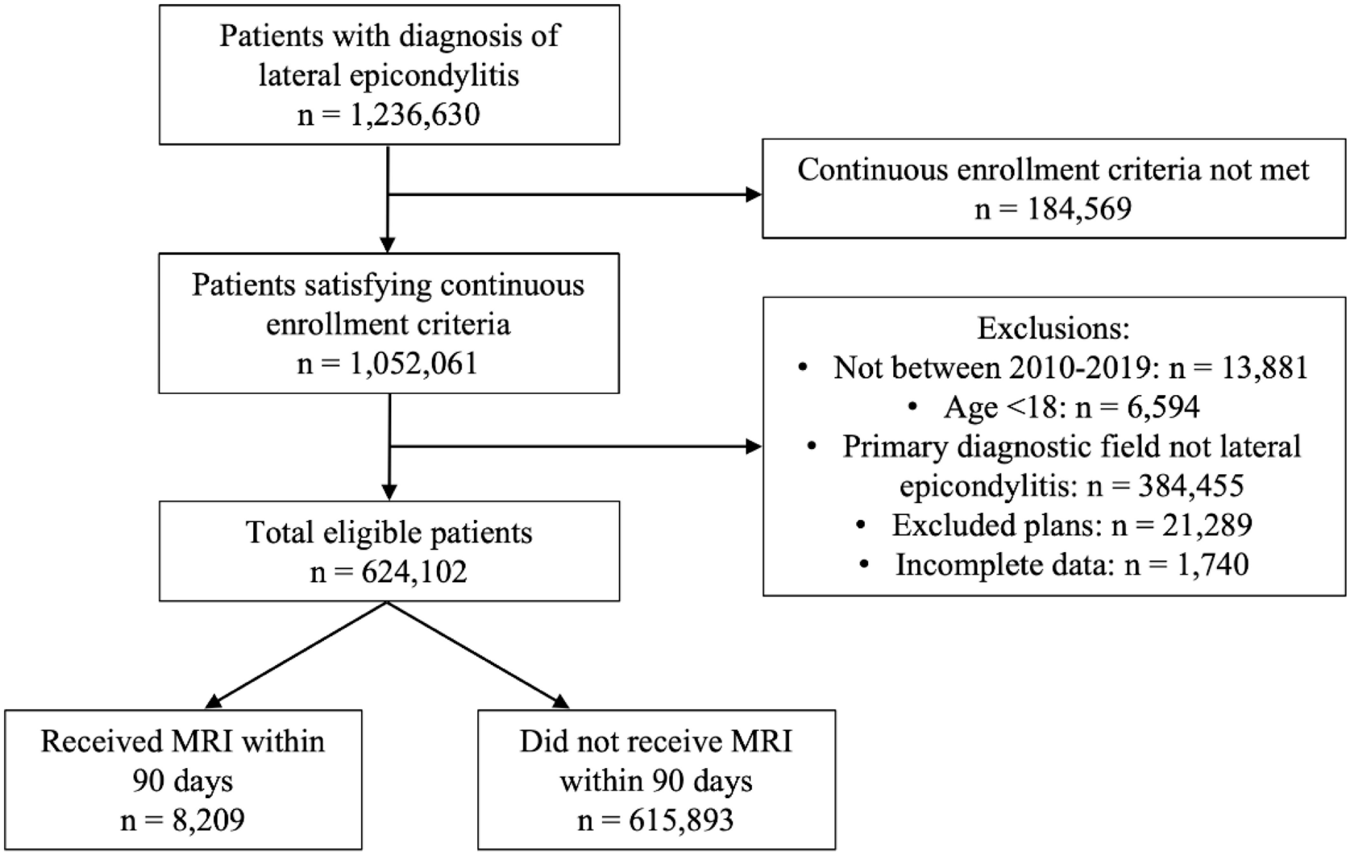

Figure 1.
Flow diagram of cohort creation.

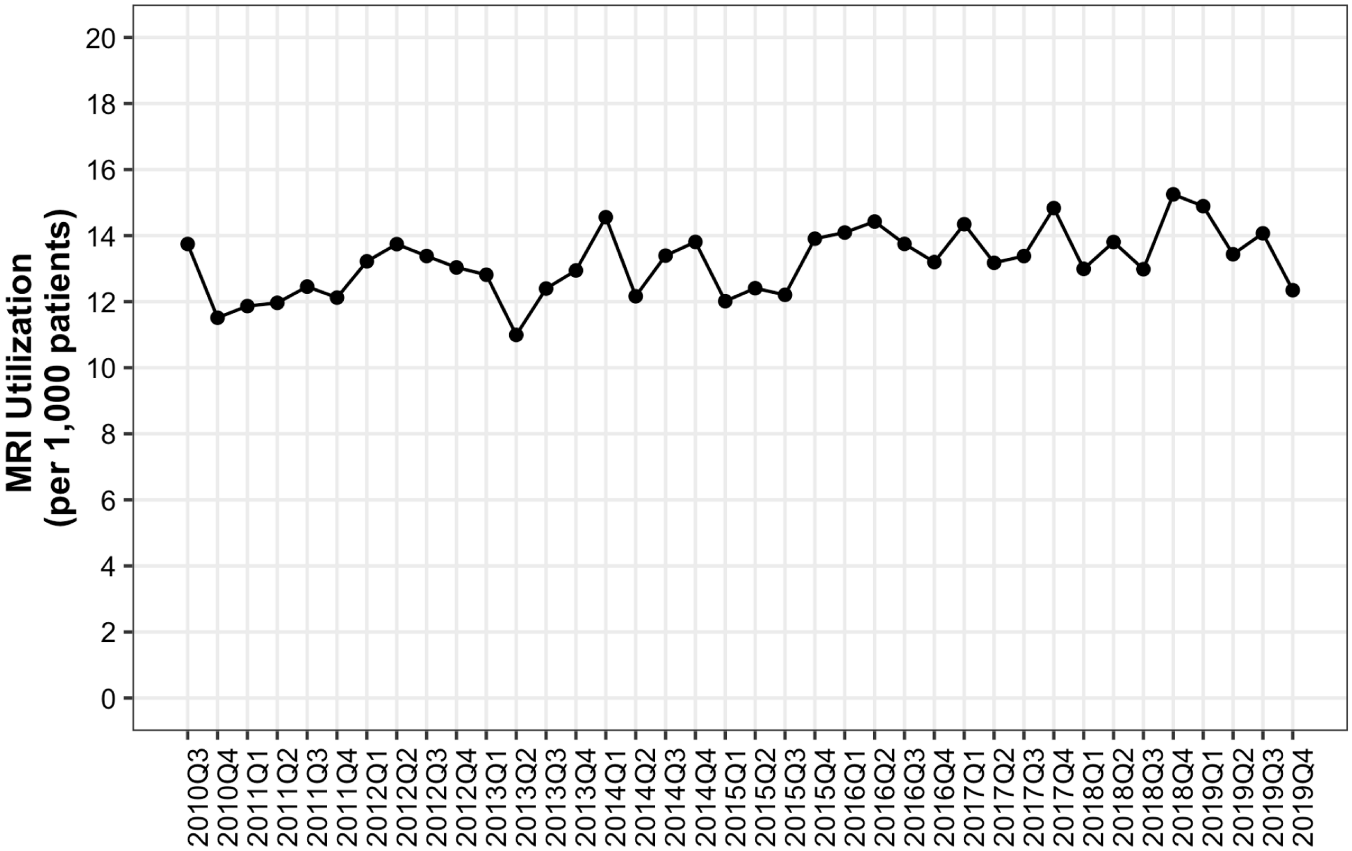

Figure 2.

Overall yearly trends in use of MRI for lateral epicondylitis. Utilization was defined as the proportion of patients diagnosed with lateral epicondylitis in a given year who received MRI multiplied by 1,000.

Table 1.

ICD and CPT Codes Used.

Diagnosis or Procedure	ICD-9/10 or CPT Code
Lateral epicondylitis	ICD-9-D-72632, ICD-10-D-M7710, ICD-10-D-M7711, ICD-10-D-M7712
Elbow MRI	CPT-73221, CPT-73222, CPT-73223
Surgical management	CPT-24006, CPT-24100, CPT-24101, CPT-24102, CPT-24357, CPT-24358, CPT-24359
Steroid injection	CPT-20550, CPT-20551
Physical/occupational therapy	CPT-97161, CPT-97162, CPT-97163, CPT-97164, CPT-97165, CPT-97166, CPT-97167, CPT-97168, CPT-97010, CPT-97012, CPT-97014, CPT-97016, 97018, CPT-97022, CPT-97024, CPT-97026, CPT-97028, CPT-97032, CPT-97033, CPT-97034, CPT-97035, CPT-97036, CPT-97110, CPT-97112, CPT-97113, CPT-97124, CPT-97140, CPT-97530, CPT-97760

ICD = International Classification of Diseases. CPT = Current Procedural Terminology. MRI = magnetic resonance imaging.

Table 2.

Demographic attributes of individuals undergoing MRI or not undergoing MRI for lateral epicondylitis (univariate comparisons)

Variable	Received MRI (n = 8,209)	Did Not Receive MRI (n = 615,893)	p-value
Age range, n (%)			<0.001
45 years	2,805 (34.2)	168,905 (27.4)	
45–64 years	5,038 (61.4)	378,732 (61.5)	
≥65 years	366 (4.5)	68,256 (11.1)	
Sex, n (%)			0.001
Male	3,511 (42.8)	274,294 (44.5)	
Female	4,698 (57.2)	341,599 (55.5)	
Region, n (%)			<0.001
Midwest	2,070 (25.2)	154,184 (25.0)	
Northeast	2,358 (28.7)	160,149 (26.0)	
South	2,876 (35.0)	216,093 (35.1)	
West	905 (11.0)	85,467 (13.9)	
Insurance, n (%)			<0.001
Commercial	7,514 (91.5)	538,063 (87.4)	
Medicare Advantage	306 (3.7)	30,939 (5.0)	
Medicaid	389 (4.7)	46,891 (7.6)	
ECI, mean (SD)	2.65 (2.61)	2.40 (2.52)	<0.001

Table 3.

Incidence of surgery, steroid injections, and PT/OT in MRI and no MRI cohorts.

Events	Received MRI (n = 8,209)	Did Not Receive MRI (n = 615,893)	p-value
Surgical management, n (%)	2,326 (28.3)	17,531 (2.8)	<0.001
Midwest	660 (8.0)	5,111 (0.8)	
Northeast	597 (7.3)	4,059 (0.7)	
South	853 (10.4)	6,487 (1.1)	
West	216 (2.6)	1,874 (0.3)	
Steroid injection, n (%)	2,772 (33.8)	91,560 (14.9)	<0.001
Midwest	750 (9.1)	22,557 (3.7)	
Northeast	733 (8.9)	23,010 (3.7)	
South	1,015 (12.4)	35,535 (5.8)	
West	274 (3.3)	10,458 (1.7)	
Physical/occupational therapy, n (%)	1,858 (22.6)	85,870 (13.9)	<0.001
Midwest	483 (5.9)	19,900 (3.2)	
Northeast	636 (7.7)	31,202 (5.1)	
South	543 (6.6)	22,956 (3.7)	
West	196 (2.4)	11,812 (1.9)	

Table 4.

Costs of treatment in US Dollars*.

Procedure	Reimbursement, mean (SD)
MRI	950 (1,040)
South region	882 (1,021)
Northeast region	876 (904)
Midwest region	1,130 (1,191)
West region	924 (977)
Surgical management	2,273 (2,503)
Steroid injection	202 (288)
Physical/occupational therapy	2,882 (6,271)

SD = standard deviation. MRI = magnetic resonance imaging.

*Descriptive statistics reported

Table 5.

Relevant time intervals*.

Interval	Time, mean (SD)
Initial diagnosis to MRI	300 (457) days
Insurance type	
Commercial insurance	305 (463) days
Medicare Advantage	299 (487) days
Medicaid	310 (431) days
Region	
South	282 (436) days
Northeast	302 (467) days
Midwest	325 (482) days
West	306 (457) days

SD = standard deviation. MRI = magnetic resonance imaging.

*Descriptive statistics reported