ORIGINAL RESEARCH

Comparing Outcomes of Musculoskeletal Radiographs from In-Person and Telemedicine Primary Care Cohorts, April 2019–June 2021

John Petrilli, MD, FAAFP, Taylor Guth, BS, and Emily Coughlin, MPH

Purpose: **Musculoskeletal conditions are a common reason for primary care visits, and they are being increasingly addressed at televisits. We therefore examined outcomes of musculoskeletal radiographs ordered at in-person and telemedicine primary care visits, which have implications for patient care and the economic impact of telemedicine.**

Methods: **We performed a retrospective cohort study of musculoskeletal radiograph orders placed April 1, 2019–March 31, 2021 at a major academic health system. Radiology reports were classified as normal or abnormal based on the radiologist's impression. Findings were compared using c^2 tests.**

Results: **The main outcome was radiographic abnormalities. A secondary outcome was the effect of social determinants of health and medical comorbidities on telemedicine utilization. A total of 1580 radiographs were reviewed. Compared with televisits occurring after onset of the SARS-Cov2-19 pandemic, radiographs ordered at in-person visits had higher odds of being abnormal (OR 2.51, 95% CI 1.33–4.75; *P = .004*). When comparing radiographic outcomes at in-person visits before and after the pandemic's onset, those ordered afterward had higher odds of being abnormal (OR 1.88, 95% CI 1.30–2.71; *P < .001*). Social determinants of health and medical comorbidities were not associated with telemedicine utilization.**

Conclusions: **After the onset of the SARS-Cov2-19 pandemic, radiographs ordered at in-person visits had higher odds of being abnormal compared with televisits. These findings indicate that prudence should be applied to ordering musculoskeletal radiographs in telemedicine encounters. (J Am Board Fam Med 2023;36:739–745.)**

Keywords: **Clinical Medicine, Delivery of Health Care, Family Medicine, Musculoskeletal Diseases, Orthopedics, Primary Health Care, Radiography, Retrospective Studies, Social Determinants of Health, Telemedicine**

Introduction

Musculoskeletal conditions are a common reason for primary care encounters, with approximately 10 to 20% of the population presenting annually for a musculoskeletal complaint.[1,2] However, the SARS-CoV-2-19 pandemic led to rapid changes in the delivery of primary care with more frequent utilization of telemedicine,[3] and studies show that the content of televisits differs from that of in-person visits.[4,5] Primary care clinicians are deciding which conditions are best managed via televisits, though data on actual outcomes is lacking.[6–8] Clinicians are unsure if telemedicine is an appropriate medium to evaluate musculoskeletal complaints, largely due to the difficulty performing a complex physical examination.[9,10]

Efforts are being made to train primary care physicians to perform virtual musculoskeletal exams[11] and to evaluate the effectiveness of virtual musculoskeletal exams.[12] However, to our knowledge there are no

This article was externally peer reviewed.

Submitted 11 March 2023; revised 6 June 2023; accepted 12 June 2023.

From the Department of Family Medicine, University of South Florida Morsani College of Medicine (JP); University of South Florida Morsani College of Medicine Tampa, FL (TG); Department of Medical Education, University of South Florida Morsani College of Medicine, Tampa, FL (EC).

Funding: Ms. Guth received a stipend for this work from the USF Morsani College of Medicine, the Office of RISE.

Conflict of interest: The authors have no conflicts of interest to disclose.

Corresponding author: John Petrilli, MD, FAAFP, Department of Family Medicine, University of South Florida Morsani College of Medicine, 13220 USF Laurel Dr. Tampa, FL 33612 (E-mail: jpe@usf.edu).

studies comparing outcomes for musculoskeletal radiographs ordered at virtual visits to in-person visits. Primary care physicians order radiographs at up to 25% of encounters for musculoskeletal conditions,[13] so the implications for patient care and costs to the health system and society are not insignificant.

Therefore, we examined the results of radiographs ordered at in-person and telemedicine visits before and after onset of the pandemic. People with low English proficiency, age 65 or older, Black race, Latinx ethnicity, female sex, lack of prior telecommunications use, lower household income, and enrollment in Medicaid have been shown to use telemedicine less than others.[14–16] Therefore, as a secondary outcome we explored the association between social determinants of health and medical comorbidities with telemedicine utilization. We hypothesized that radiographs ordered at televisits would have fewer radiographic abnormalities than those ordered at in-person visits. In addition, we hypothesized that patients using telemedicine during the COVID-19 pandemic would be younger and English-speaking.

Methods

Study Design

The study utilized a retrospective cohort design. We queried the electronic health record from April 1, 2019 to March 31, 2021 at a large academic health system. Adult primary care patients were included if they had a visit containing ICD-10 codes beginning with M or S (musculoskeletal codes) for which a radiograph was ordered. The university's IRB approved the study.

Data Collection

Patient characteristics included medical record number, race, ethnicity, language, gender, age, payor group, median household income based on postal code,[17] and comorbid ICD-10 codes for calculating an age-adjusted Charleson comorbidity index (CCI). Characteristics of orders included ICD-10 code, anatomic area of the radiograph, date of the order, encounter type (telemedicine or in-person), and date radiograph was completed. Our institution's policy was to use video televisits and convert to telephone-only if the video failed. We were unable to differentiate video from telephone televisits.

One of the authors personally reviewed the radiograph reports and coded the findings as normal or abnormal based on the radiologist's impression. If there was uncertainty regarding the impression, we conferred and came to consensus. The primary finding was also recorded, as documented by the radiologist's impression on the radiology report. When applicable, the primary finding's severity was included as stated by the radiology report (eg, moderate osteoarthritis). The authors categorized abnormal findings into groupings including spinal spondylosis, fracture, mild osteoarthritis, moderate or advanced osteoarthritis, other diagnosis, and missing result.

Data Analysis

Patient characteristics were analyzed only for unique patients, because some patients underwent multiple radiographs. Categorical data were summarized using frequencies and proportions, whereas continuous data were summarized as mean ± standard deviation. Chi-square tests were used to compare categorical variables, whereas due to non-normal distribution, nonparametric Mann-Whitney *U* test were used to compare continuous variables of age, household income, and age-adjusted CCI.

Radiographs were analyzed per-order and organized into 3 categories: those ordered at in-person visits before April 1, 2020, in-person visits on or after April 1, 2020, and televisits on or after April 1, 2020. We chose April 1, 2020, as the cutoff, because that is when our institution began using telemedicine. Radiographs were analyzed per-order instead of per-patient, so as to avoid introduction of selection bias for patients who underwent multiple radiographs. Orders with missing results were excluded. Proportions of abnormal findings were compared using Chi-square tests. Results were reported as Pearson's c^2 p-values and Mantel Haenszel odds ratios (OR) with 95% confidence intervals (95% CI). OR were unadjusted as none of the patient factors were statistically significant. All p-values less than $\alpha = 0.05$ were considered statistically significant. Analysis was conducted using SPSS Version 27.

Results

A total of 1580 radiograph orders were analyzed for 995 unique patients. Patients were mostly female (n = 623, 63%), white (n = 668, 69%), and non-Latinx (n = 831, 86%). The average age was 62.9 ± 15.2 years. Table 1 displays patient characteristics and their

Table 1. Patient Characteristics and Association with Telemedicine Use[a]

Characteristic	Overall (n = 995)	Patients with visits after April 2020 (n = 504)			
		Did Not Utilize Telemedicine (n = 418)	Utilized Telemedicine (n = 89)	OR (95% CI)	*p*-Value
Gender				1.59 (0.98–2.59)	0.062
Man	372 (37.4)	175 (42.2)	28 (31.5)		
Woman	623 (62.6)	240 (57.8)	61 (68.5)		
Race					0.965
White	668 (67.1)	279 (68.7)	59 (67.8)		
African American	188 (18.9)	79 (19.5)	18 (20.7)		
Other	112 (11.3)	48 (11.8)	10 (11.5)		
Ethnicity				0.444 (0.196–1.01)	0.05
Not Hispanic/Latinx	831 (83.5)	336 (83.4)	79 (91.9)		
Hispanic/Latinx	131 (13.2)	67 (16.6)	7 (8.1)		
Language				0.249 (0.033–1.90)	0.221
English	945 (95.0)	394 (95.6)	88 (98.9)		
Other	46 (4.6)	18 (4.4)	1 (1.1)		
Payor Group					0.586
Commercial	346 (34.8)	139 (43.0)	43 (48.9)		
Medicaid	8 (0.8)	3 (0.9)	2 (2.3)		
Medicare	261 (26.2)	93 (28.8)	24 (27.3)		
Medicare Advantage	211 (21.2)	83 (25.7)	18 (20.5)		
Other	18 (1.8)	5 (1.5)	1 (1.1)		
Age (yrs)	62.94 ± 15.22	62.43 ± 15.27	59.71 ± 14.97		0.078
Age-adjusted CCI	3.68 ± 2.03	3.60 ± 2.02	3.66 ± 1.96		0.875
Median household income ($)	58,942 ± 22,146	58,380 ± 21,701	57, 065 ± 22,240		0.552

Abbreviations: OR, Odds ratio; CI, Confidence interval; CCI, Charleson comorbidity index.
[a]Data presented as N (%) or mean ± standard deviation.

relationship to telemedicine utilization. Radiographs done before April 1, 2020 were all ordered at in-person visits (n = 812, 51%). Radiographs done after April 1, 2020 (n = 768) were ordered at either in-person (n = 636, 40%) or telemedicine visits (n = 132, 8%). Among patients who visited after April 1, 2020 (n = 507), 89 (18%) utilized telemedicine. Patients who are non-Latinx were more likely to use telemedicine (*P* = *.046*), although the odds ratio was not statistically significant (OR 0.444, 95% CI 0.196–1.005).

We conducted a qualitative post hoc review of results for patients who underwent multiple radiographs. Multiple radiographs were ordered on 371 of the patients over the course of the 2-year span. Of these, 72 pairs of radiographs either overlapped anatomic sites or were of the same site at separate points in time. Sixty-seven of the pairs were ordered at in-person appointments, and 49 of these pairs had concordant abnormal results. The abnormal results were relatively equally distributed before and after the pandemic's onset (22 pairs each), and 5 of the pairs were separated by the pandemic's onset.

Table 2 compares radiograph findings between the 3 visit-types. Results were available for 1075 orders (68%). Radiographs from in-person visits after the pandemic's onset showed a significantly increased odds of abnormal findings compared with radiographs ordered at televisits (OR 2.51, 95% CI 1.33–4.75; *P* = *.004*). Radiographs ordered at in-person visits after the pandemic's onset showed a significantly higher odds of abnormal findings compared with those ordered before the pandemic's onset (OR 1.88, 95% CI 1.30–2.71; *P* < *.001*). Table 3 shows the proportion of normal and abnormal radiograph diagnoses among the groups, including a breakdown of abnormal findings. "Fracture" was by far the most common severe finding. There were 2 radiographs with erosions and 1 radiograph with evidence of osteomyelitis, which were included in "other diagnoses" due to their low frequency.

Table 2. Comparisons between Outcomes for Radiographs Ordered at In-Person and Telemedicine Visits, Pre- and Post-Pandemic Onset

Comparisons[a]	Normal Findings[b]	Abnormal Findings[b]	OR (95% CI)	*p*-Value
1. Post-onset, in-person versus telemedicine			2.51 (1.33–4.75)	0.004
Post-onset, in-person	47 (10.9)	384 (89.1)		
Post-onset, telemedicine	16 (23.5)	52 (76.5)		
2. In-person, post-versus pre-onset			1.88 (1.30–2.71)	<0.001
Post-onset, in-person	47 (10.9)	384 (89.1)		
Pre-onset, in-person	107 (18.7)	466 (81.3)		

Abbreviations: OR, Odds ratio; CI, Confidence interval.
[a]Does not include missing data.
[b]Data presented as N (%).

Discussion

The literature has repeatedly called for studies evaluating actual outcomes of televisits.[6–8] Yet in 2022, the authors of a systematic review of orthopedic televisits still concluded that "further studies are needed to determine whether telemedicine consultations from the patient's own home are truly reliable and achievable."[18] To our knowledge, this study is the first to explore outcomes of radiographs ordered at televisits.

The results indicate that primary care physicians may overutilize musculoskeletal radiographs at televisits. A possible explanation for these results is that, during the height of the pandemic, patients with minor symptoms avoided in-person visits, whereas patients with more severe conditions sought in-person care. The idea of patient self-selection accords with a survey of primary care patients who delayed care for orthopedic concerns that arose during the pandemic.[19] A study of Medicare patients found that up to 45% of them avoided medical facilities during the pandemic for fear of contracting the virus.[20] Delaying care may have inflated radiographic abnormalities for in-person visits that occurred after the height of the pandemic. Ongoing surveillance is needed to see if this trend persists.

Alternatively, physicians may have overutilized radiographs at televisits to compensate for the lack of a tactile physical examination. Unfortunately, the literature on imaging outcomes from virtual visits is sparse. A study looking specifically at patients presenting for low back pain found that less imaging was ordered for patients presenting virtually compared with in-person.[21] However, national guidelines recommend against routine imaging for low back pain,[22] and the

Table 3. Outcomes of Musculoskeletal Radiographs by Visit Type, and Breakdown of the Primary Finding of Abnormal Radiographs

	Before Onset, In-person[a]	After Onset, In-person[a]	After Onset, Telemedicine[a]
Missing	239	205	64
Normal findings	107 (18.7)	47 (10.9)	16 (23.5)
Abnormal findings	466 (81.3)	384 (89.1)	52 (76.5)
Primary abnormality:			
Spinal spondylosis	157 (27.4)	95 (22.0)	17 (25.0)
Fracture	20 (3.5)	29 (6.7)	2 (2.9)
Mild osteoarthritis	140 (24.4)	119 (27.6)	16 (23.5)
Moderate/advanced osteoarthritis	88 (15.4)	83 (19.3)	12 (17.6)
Other diagnosis[b]	61 (10.6)	58 (13.5)	5 (7.4)

[a]Data presented as N(%). Percentages are calculated excluding missing results.
[b]Other diagnoses included calcific tendinitis, enthesopathy, erosions (2 radiographs), joint effusion, osteomyelitis (1 radiograph), osteopenia, postsurgical changes, and soft tissue changes.

study did not explicitly look at imaging results. A study of virtual and in-person encounters for abdominal complaints in the ER found that, compared with the in-person evaluation, clinicians performing the virtual evaluation ordered less imaging.[23] Records from the ER televisits documented greater diagnostic uncertainty, and the authors hypothesized that concerns about cost and imaging utilization may have led the virtual clinicians to order less imaging. Clinical uncertainty may also explain the results of our study. Clinicians may have ordered imaging at televisits to compensate for the lack of a reliable physical examination. A virtual musculoskeletal examination has been shown to provide good accuracy for elements like range of motion, but special tests are more difficult to perform.[12] Multiple studies document the challenges that physicians and patients face when engaging in a virtual musculoskeletal examination, including the potential need for caregiver assistance, appropriateness of the patient's environment, poor visualization, low inter-rater reliability, and technical issues such as video lag.[24–27] Clinicians should not underestimate the harms of an incomplete or inaccurate physical examination,[28] though a growing familiarity with the virtual musculoskeletal examination[11] might impact future ordering patterns for radiographs. Forthcoming studies could evaluate which components of the in-person visit (eg, history and/or physical examination) best correlate with the need for musculoskeletal imaging.

In an age mindful of cost and resource utilization, we should also consider the economic impact of primary care televisits for musculoskeletal conditions. Prior studies exploring health systems and societal costs of orthopedic televisits did not specifically consider the cost of imaging; they either ignored imaging or assumed costs were similar for televisits.[13,29] Our study's findings challenge this assumption. Telemedicine does not routinely reduce the cost of health care, largely due to the costs associated with technology upkeep and maintenance.[30] It has the potential to reduce health care costs if it mitigates expensive procedures and specialist referral,[30] but our study indicates that televisits may be less than ideal for musculoskeletal conditions. Unnecessary radiography would increase health care costs (in 2022 CMS reimbursed $34.26 for CPT 73030, multi-view shoulder radiograph)[31] and further mitigate any savings to the health system gained by the televisit. Furthermore, telemedicine's societal benefits are largely attributable to the decreased costs of travel and missed work.[32] If telemedicine utilization is associated with unnecessary imaging orders, however, the need for travel to an imaging facility and time off of work would moderate the savings to society.

This study found no significant association between social determinants of health or comorbidities and telemedicine utilization, which contrasts with much of the existing literature.[14–16] Local factors and the population studied likely account for this. We did see trends toward significance with age and ethnicity.

Our study has several limitations. As telemedicine becomes a regular medium for ambulatory visits, care must be taken to contextualize these results, which were obtained during the height of the COVID-19 pandemic. A major limitation of this study is that imaging outcomes were not compared with a patient's documented symptoms in the medical record. Radiographic abnormalities may therefore be incidental findings. However, any error introduced from this would likely be nondifferential, because incidental findings would be present in all groups. Another limitation of the study involves the per-order analysis approach. A per-patient approach could have been used, but it would be more likely to introduce selection bias, because only 1 radiograph per patient could be chosen. Qualitative review of the results found that, of the patients who obtained multiple radiographs of a similar anatomic site, the proportion of concordant abnormal results were similar before and after the pandemic's onset. Lastly, as a retrospective cohort study, we could not control the size of the cohorts. The number of radiographs from televisits were relatively small compared with those ordered at in-person visits. Nevertheless, retrospective data such as this is valuable, because there is so little evidence of telemedicine's actual outcomes. In addition, the unpredictability of patients' concerns makes a prospective primary care cohort difficult to arrange, and randomizing musculoskeletal concerns to telemedicine or in-person visits would be difficult to do in the primary care setting.

In summary, radiographs ordered at in-person primary care visits after the pandemic's onset had higher odds of being abnormal compared with televisits. These findings indicate that prudence should

be applied to ordering musculoskeletal radiographs in telemedicine encounters.

The authors would like to acknowledge Dr. Rahul Mhaskar for his contributions to the statistical analysis.

To see this article online, please go to: http://jabfm.org/content/36/5/739.full.

References

1. MacKay C, Canizares M, Davis AM, Badley EM. Health care utilization for musculoskeletal disorders. Arthritis Care Res (Hoboken) 2010;62:161–9.
2. Wilder MH. Prevalence of chronic skin and musculoskeletal conditions, United States-1969. Vital Health Stat 1974;10:1–65.
3. Patel SY, Mehrotra A, Huskamp HA, Uscher-Pines L, Ganguli I, Barnett ML. Variation in telemedicine use and outpatient care during the COVID-19 pandemic in the United States. Health Aff (Millwood) 2021;40:349–58.
4. Alexander GC, Tajanlangit M, Heyward J, Mansour O, Qato DM, Stafford RS. Use and content of primary care office-based vs telemedicine care visits during the COVID-19 pandemic in the US. JAMA Netw Open 2020;3:e2021476.
5. Reed M, Huang J, Graetz I, Muelly E, Millman A, Lee C. Treatment and follow-up care associated with patient-scheduled primary care telemedicine and in-person visits in a large integrated health system. JAMA Netw Open 2021;4:e2132793-e2132793.
6. Shigekawa E, Fix M, Corbett G, Roby DH, Coffman J. The current state of telehealth evidence: a rapid review. Health Aff (Millwood) 2018;37:1975–82.
7. Hersh WR, Hickam DH, Severance SM, Dana TL, Krages KP, Helfand M. Diagnosis, access and outcomes: Update of a systematic review of telemedicine services. J Telemed Telecare 2006;12:3–31.
8. Hailey D, Ohinmaa A, Roine R. Study quality and evidence of benefit in recent assessments of telemedicine. J Telemed Telecare 2004;10:318–24.
9. Nies S, Patel S, Shafer M, Longman L, Sharif I, Pina P. Understanding physicians' preferences for telemedicine during the COVID-19 pandemic: cross-sectional study. JMIR Form Res 2021;5:e26565.
10. Ward K, Vagholkar S, Sakur F, Khatri NN, Lau AYS. Visit types in primary care with telehealth use during the COVID-19 pandemic: systematic review. JMIR Med Inform 2022;10:e40469.
11. Yedlinsky NT, Peebles RL. Telemedicine management of musculoskeletal issues. Am Fam Physician 2021;103:147–54.
12. Ansary AM, Martinez JN, Scott JD. The virtual physical exam in the 21st century. J Telemed Telecare 2021;27:382–92.
13. Mäntyselkä PT, Kumpusalo EA, Ahonen RS, Takala JK. Direct and indirect costs of managing patients with musculoskeletal pain-challenge for health care. Eur J Pain 2002;6:141–8.
14. Hsueh L, Huang J, Millman AK, et al. Disparities in use of video telemedicine among patients with limited English proficiency during the COVID-19 pandemic. JAMA Netw Open 2021;4:e2133129.
15. Eberly LA, Kallan MJ, Julien HM, et al. Patient characteristics associated with telemedicine access for primary and specialty ambulatory care during the COVID-19 pandemic. JAMA Netw Open 2020;3:e2031640.
16. Crotty BH, Hyun N, Polovneff A, et al. Analysis of clinician and patient factors and completion of telemedicine appointments using video. JAMA Netw Open 2021;4:e2132917.
17. United States Census Bureau. Accessed September 5, 2021, Available at: https://data.census.gov/cedsci/all?q=median%20income.
18. Haider Z, Aweid B, Subramanian P, Iranpour F. Telemedicine in orthopaedics during COVID-19 and beyond: a systematic review. J Telemed Telecare 2022;28:391–403.
19. Atherly A, Van Den Broek-Altenburg E, Hart V, Gleason K, Carney J. Consumer reported care deferrals due to the covid-19 pandemic, and the role and potential of telemedicine: cross-sectional analysis. JMIR Public Health Surveill 2020;6:e21607.
20. Findling MG, Blendon RJ, Benson JM. Delayed care with harmful health consequences—reported experiences from national surveys during coronavirus disease 2019. JAMA Health Forum 2020;1:e201463.
21. Baughman D, Ptasinski A, Baughman K, Buckwalter N, Jabbarpour Y, Waheed A. Comparable quality performance of acute low-back pain care in telemedicine and office-based cohorts. Telemed J E Health 2022;28:1579–86.
22. Imaging Tests for Lower-Back Pain. Choosing Wisely. Accessed November 10, 2022, Available at: https://www.choosingwisely.org/patient-resources/imaging-tests-for-back-pain/.
23. Hayden EM, Borczuk P, Dutta S, et al. Can video-based telehealth examinations of the abdomen safely determine the need for imaging? J Telemed Telecare 2021;0:1357633X2110233.
24. Mammen JR, Elson MJ, Java JJ, et al. Patient and Physician Perceptions of Virtual Visits for Parkinson's Disease: A Qualitative Study. Telemed J E Health 2018;24:255–67.
25. Kemp MT, Liesman DR, Williams AM, et al. Surgery Provider Perceptions on Telehealth Visits During the COVID-19 Pandemic: Room for Improvement. J Surg Res 2021;260:300–6.
26. Hoenig H, Tate L, Dumbleton S, et al. A quality assurance study on the accuracy of measuring

physical function under current conditions for use of clinical video telehealth. Arch Phys Med Rehabil 2013;94:998–1002.

27. Yager PH, Clark ME, Dapul HR, Murphy S, Zheng H, Noviski N. Reliability of circulatory and neurologic examination by telemedicine in a pediatric intensive care unit. J Pediatr 2014;165:962–6.e1-5.
28. Reeves JJ, Ayers JW, Longhurst CA. Telehealth in the COVID-19 Era: A Balancing Act to Avoid Harm. J Med Internet Res 2021;23:e24785.
29. Buvik A, Bergmo TS, Bugge E, Smaabrekke A, Wilsgaard T, Olsen JA. Cost-effectiveness of telemedicine in remote orthopedic consultations: randomized controlled trial. J Med Internet Res. 2019;21:e11330.19.
30. Snoswell CL, Taylor ML, Comans TA, Smith AC, Gray LC, Caffery LJ. Determining if telehealth can reduce health system costs: scoping review. J Med Internet Res 2020;22:e17298.
31. 2022 Medicare physician fee schedule: impacts for 70,000 Series CPT codes. American College of Radiology. Accessed January 28, 2023, Available at: https://www.acr.org/-/media/ACR/NOINDEX/Advocacy/Advocacy-News/2022-MPFS/Impact-Table-70000-Series.pdf.
32. Ufholz K, Sheon A, Bhargava D, Rao G. Telemedicine preparedness among older adults with chronic illness: survey of primary care patients. JMIR Form Res 2022;6:e35028.