ORIGINAL RESEARCH

Is There a Correlation Between the Driving Distance to Healthcare Facilities and Postoperative Complications After Achilles Tendon Rupture Surgical Repair? A Geospatial Study

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Abstract

Background: Geospatial access to healthcare is defined as the ability of patients to obtain healthcare services based on their locations. Therefore, we aimed to investigate patients' proximity to healthcare and its correlation with the complications of surgically treated Achilles tendon rupture (ATR) including venous thromboembolism (VTE), rerupture, and wound problems.

Methods: We included 426 patients who lived in the United States (US) Tri-State Area with surgically treated for ATR. We used patient and hospital addresses and zip codes to calculate the distances to healthcare centers. The Shapiro–Wilk test was used to determine normal distribution. Mann–Whitney *U* test was used to compare the groups with and without complication. The point biserial correlation test was used to determine any correlations between driving distance and the incidence of complications ($p < 0.05$ was considered significant).

Results: The average driving distance to the patient's specific healthcare center was 62.16 ± 76.54 km. There was no significant difference between the distances for patients with and without overall complications ($p = 0.65$), with and without VTE ($p = 0.70$), with and without rerupture ($p = 0.84$), and with and without wound problems ($p = 0.36$). No correlation between complications and the distance to healthcare centers was found ($p = 0.65$).

Conclusion: Geospatial information is important within the context of healthcare accessibility and can provide crucial guidance to healthcare planning for patients and healthcare policymakers. Although this study showed that driving distance to healthcare facilities did not lead to significantly higher complication rates amongst ATR patients, it does not resolve the need for further studies looking at a larger population and wider geographical segments.

Keywords: Geographic distribution, Geographic information system, Healthcare accessibility, Healthcare equity, Social determinants of health.

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Introduction

Achilles tendon ruptures (ATR) is a prevalent injury that commonly occurs 2–6 cm proximal to the calcaneus insertion and is often attributed to high-impact sports such as basketball, soccer, or racket games.[1–4] Many patients end up with the surgical treatment of ATR that can bring about complications including, but not limited to infection, rerupture, sural nerve injury, hypertrophic scars, and VTE. Many studies have been conducted on the risk factors for these complications; however, there is a paucity of the relationship between ATR complications and patients' social determinants of health data including proximity to the healthcare center.[4,5] While current ATR studies examine complication rates from a more technical aspect, primarily attributed to the mechanics of the procedure, the lack of information about access to care warrants further analysis and provides a unique perspective and opportunity to identify gaps in the treatment process.

Geospatial access to healthcare is defined as the ability to obtain healthcare services based on the patient's proximity to appropriate healthcare facilities which can include travel effort, cost, and distance.[6] Previous reports have shown that geospatial access is associated with postoperative complications in patients who received surgical treatments for various pathologies.[7,8] Patients' location also plays a role in postoperative outcomes such as Patient-Reported Outcomes

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Measurement Information System, depression, anxiety, and pain interference.[9,10] Accessibility to care has received a recent peak of interest and is defined as the ability to improve healthcare equity and to help people improve or preserve their health by utilizing appropriate healthcare resources.[11] Access to care has been linked to better health benefits and reduced health system costs.[12]

There are a limited number of studies exploring how proximity to the treating hospital affects accessibility to care and subsequent complications in ATR surgical repair.[13,14] To the best of our knowledge, no study examines the geospatial relationship between ATR complications and the proximity of care to the treating hospital. Therefore, we conducted this study to investigate geospatial accessibility to healthcare centers, and its correlation with ATR complications after surgical repair, including VTE, rerupture, and wound problems.

Methods

Study Design

After receiving Institutional Review Board (No. 2015P000464) approval, data from patients who were surgically treated for an ATR between 2015 and 2021 were collected retrospectively. Patients were treated in an urban hospital in a large city in Massachusetts. Three tertiary care hospitals providing specialized foot and ankle surgery services were included and 426 patients met the inclusion criteria; patients weren't eligible for inclusion if they were[1] younger than 18-year-old,[2] underwent surgical treatment for Achilles, debridement, tendinopathy, tendinitis, or other Achilles tendon-related problems,[3] have previously been treated for their ATR, or[4] lived outside the US Tri-State Area (New York City, Connecticut, New Jersey, New Hampshire, Maine, Rhode Island, Pennsylvania, and Maryland).

Variables and Outcome Measures

Patient characteristics were retrieved and included age, gender, body mass index (BMI), home address, and zip code. Treatment characteristics included hospital site, address, zip code, laterality, number of re-operations, rupture date, VTE, and follow-up duration. Complications were extracted and classified as VTE occurrence, reruptures, surgical site infections (SSI), and wound dehiscence. Wound dehiscence and SSI were grouped together and referred to as wound problems in this study. Using patient home addresses, zip codes, and patient-specific treatment locations, we calculated the driving distances for the patients. The primary outcome measure was the driving distance to the hospital where the patient received surgical treatment for ATR.

Statistical Analysis

The Shapiro–Wilk test was used to assess the normality of the study data, which was noted to be not normally distributed. Hence, qualitative variables were displayed as frequencies and percentages, continuous nonparametric variables were displayed as the median and interquartile range (IQR), and parametric data were shown as mean ± standard deviation. In order to compare the distance to the healthcare center between patients with and without complications, we used the Mann–Whitney *U* test to compare the driving distance between the patients and the treating hospital. To compare the correlation between complications and driving distance, we used the point biserial correlation test. A p-value of <0.05 was considered statistically significant. All data analysis was conducted using Python software (version 3.8) and Microsoft Excel.[15]

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Geospatial Data

After screening the patients, we performed a geographic information system (GIS) platform analysis in the Tri-State Area using GIS tools such as Maptive, powered by Google Maps, to create heatmaps displaying the geographical distribution of patients treated for ATR with and without complications. The maps were made using patient addresses. The approximate distance between the treating hospitals and patient-occupied regions was measured and displayed in the figures. To calculate the driving distance for the patients, CDXGeoData technologies were used. Patient and hospital zip codes were uploaded to calculate driving distances.[16,17]

Results

The demographic data of the 426 included patients with complications are displayed in Table 1. We assessed the distance of patients to the healthcare center they received surgery for ATR. The average distance in the whole population was 62.16 ± 76.54 km. The mean distance for each complication group and their determination of normality is shown in Table 2. The median distance for each complication group and their correlation of complication with distance to healthcare are shown in Table 3. The GIS-based distribution maps of the patients with different complications, including VTE, rerupture, and wound complications, are depicted in Figure 1. The GIS distribution map of patients who did not experience complications with their ATR treatment is displayed in Figure 2.

Discussion

The study of geographical data is becoming increasingly important within the context of healthcare; living location and proximity to healthcare centers are important aspects of individuals' health provision and should be taken into consideration when looking for a care plan.[18] Our results have shown similar complication rates between controls and patients who suffered from VTE, wound problems, and rerupture, as common complications after ATR, which can be indicative of good healthcare provision in the Massachusetts area. However, this does not resolve the need for further studies within various populations to reassure the equal distribution of care centers and accessible healthcare for populations at risk of common musculoskeletal injuries such as ATR.

Assessment of access to care centers using geospatial modalities has harvested increasing attention within the context of care planning and policymaking for healthcare providers and their institutions.[6] Proximity to care is an important aspect of healthcare accessibility, as many patients are unable to get timely and adequate care for a lack of facility access. Lack of access because of distance can have several causes, including access to a mode of transportation, inadequate public transportation, limited mobility, and lack of healthcare facilities within the area of living. Some studies have reported how inequity in access to total hip and knee replacement surgeries resulted in urban areas receiving a higher rate of knee replacement based on need compared to people living in relatively more deprived areas, which translated to better health outcomes for those people who lived in urban areas.[19] Another study reported people living in rural areas as more likely to have hospitalizations or emergency department visits for acute complications compared to their urban counterparts due to their lack of access to care, thereby delaying their care and facilitating the progression of the severity of their condition.[20]

Table 1: Demographic data of patients with ATR who received surgical treatment. Data are presented as median IQR or number of patients and (%)

Characteristics		*Value*
Age		38.0 years (30.0–49.0)
BMI		26.6 (24.4–29.3)
Follow-up duration		173.0 days (96.0–216.0)
Laterality	Left	235 (55.2%)
	Right	191 (44.8%)
Gender	Female	68 (15.9%)
	Male	358 (84.0%)
Race	White	307 (72.1%)
	Black	54 (12.7%)
	Asian	36 (8.4%)
	Unavailable	29 (6.8%)
Complications		Value (*n*, %)
VTE		28 (6.5%)
Rerupture		5 (1.2%)
Wound dehiscence		9 (2.1%)
SSI		8 (1.8%)

Orthopedic surgeons should be made aware of how these policies affect their practices and the patients who seek orthopedic care. Numerous studies have previously reported evidence of inequality in access to healthcare services between rural and urban areas, with rural areas comprising greater instances of poor health outcomes, and chronic disease.[21,22] One study reported the rural cohort experienced higher rates of hip dislocation, revision surgery, wound complications, and return to the operating room for irrigation and debridement compared to the urban cohort.[23] Such results can be explained by differences between rural and urban healthcare centers based on case-volume load, infrastructure, technology, distance to travel to the hospital, and resource availability.[24]

Our results must be addressed with keeping in mind several limitations, in addition to distance from the institution, other factors should be included to present a comprehensive picture of spatial accessibility to healthcare as most disparities in access for different population types are not always apparent using travel distance alone. Furthermore, we could not assess patients who were lost to follow-up, nor those seeking care somewhere else. Additionally, the vast majority of our patients are white, middle-aged men from Massachusetts, making for an unbalanced population which adds bias to our study. It is worthwhile to note that a larger population of patients with complications after ATR surgery would increase the accuracy and reliability of the outcome of such a study.

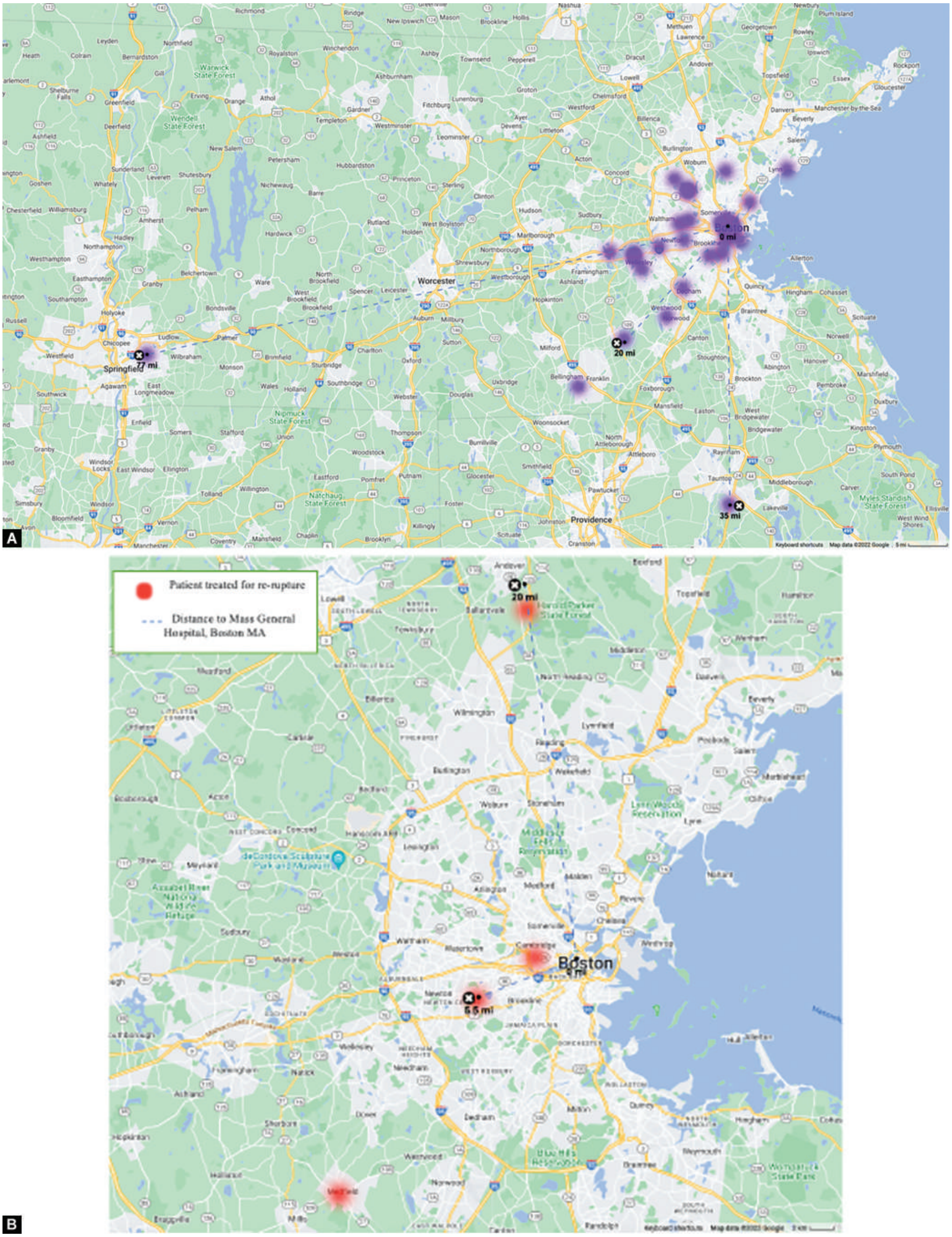
Table 2: Normal distribution analysis and correlation of the healthcare proximity (distance to healthcare) for patients with ATR who received surgical treatment with complications including VTE, rerupture, and wound problems. $p < 0.05$ was conducted statistically significant

Mean distance for patients with VTE (km)	Normality (*p*-value)	Mean distance for patients without VTE	Normality (*p*-value)	Point biserial (*p*-value)
55.75 ± 46.9	7.38	65.57 ± 88.76	5.47	0.58
Mean distance for patients with rerupture (km)	Normality (*p*-value)	Mean distance for patients without rerupture	Normality (*p*-value)	Point biserial (*p*-value)
54.04 ± 34.5	0.75	121.66 ± 86.54	4.22	0.70
Mean distance for patients with wound problems (km)	Normality (*p*-value)	Mean distance for patients without wound problems	Normality (*p*-value)	Point biserial (*p*-value)
31.175 ± 18.43	4.36	65.36 ± 89.10	2.49	0.90
Mean distance for patients with all complications (km)	Normality (*p*-value)	Mean distance for patients without complications	Normality (*p*-value)	Point biserial (*p*-value)
60.48 ± 72.36	7.22	65.98 ± 89.10	$p < 0.05$	0.65

Table 3: Comparison of the driving distances between the patients who had complications after ATR and those who did not have the complications

Complications	*Driving distance for patients with complication (median, IQR) (km)*	*Driving distances for patients with no complication (in km) (median, IQR)*	*p-value**	*Point biserial (p-value)*
VTE	43.67, 26.19	42.22, 48.35	0.69654†	0.58
Rerupture	45.73, 39.48	42.16, 47.18	0.84148†	0.70
Wound problems	30.30, 38.29	42.80, 47.57	0.36282†	0.90
All complications	42.71, 52.39	42.17, 47.24	0.16818†	0.65

IQR, interquartile range; km, kilometers; VTE, venous thromboembolism; *case group vs control group; $p < 0.05$ considered significant; †Mann–Whitney *U* test; ‡Kruskal–Wallis test



Figs 1A and B: (A) VTE in Massachusetts referred to tertiary care centers in Boston; (B) Geographic distribution of ATR patients with rerupture in Massachusetts area referred to tertiary care centers in Boston

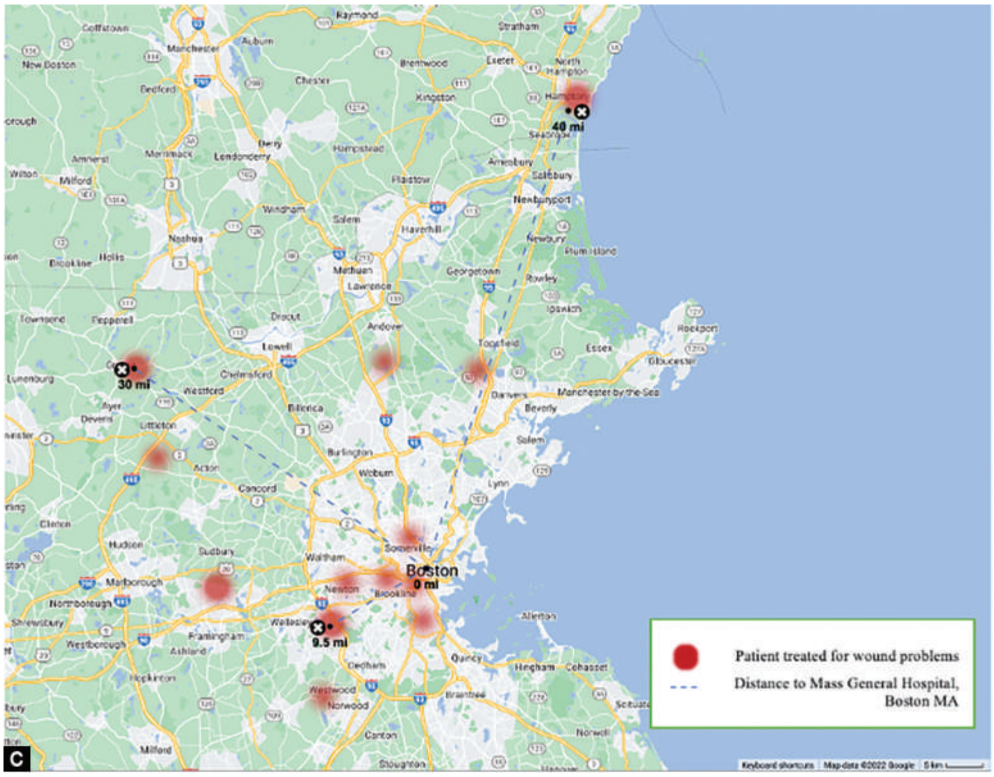


Fig. 1C: (C) Geographic distribution of ATR patients with wound complications in Massachusetts area referred to tertiary care centers in Boston

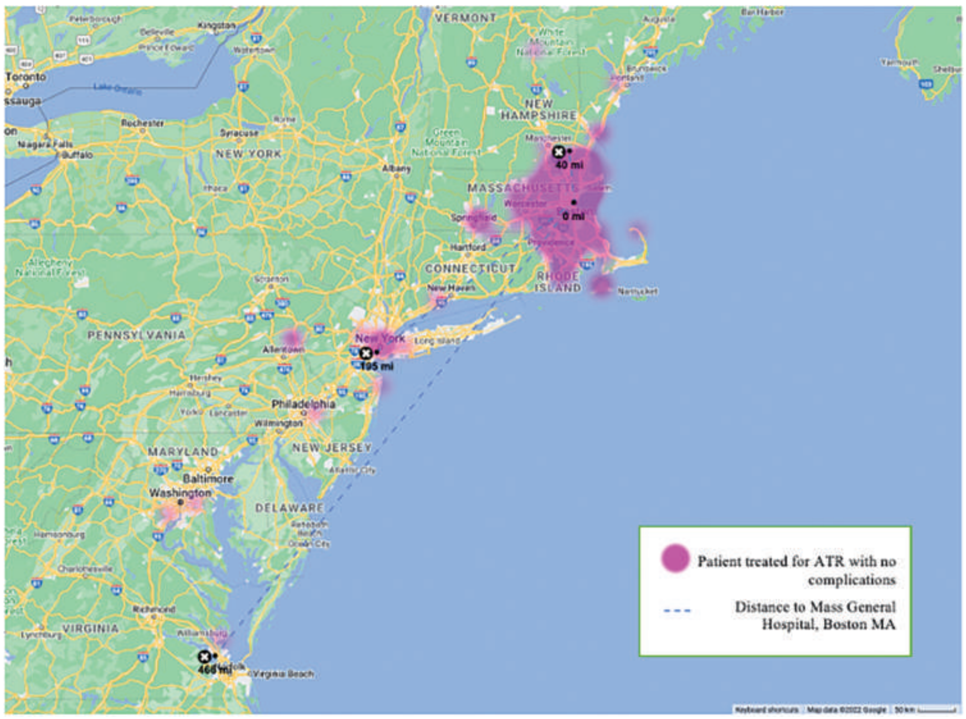


Fig. 2: Geographic distribution of ATR patients with no complications within 500 miles radius from tertiary care centers in Boston

Including other institutions in various states would also increase the generalizability of the results. We also had to restrict our study of patients to the US Tri-State Area, which prevented the utilization of patient data outside this geographical margin, thus limiting the generalizability of our findings.

Conclusion

Geospatial research is an important aspect of healthcare and should be incorporated within healthcare institutions and individual patient care plans. Being able to physically get to a healthcare facility in a timely manner is crucial for patients, particularly in trauma settings, as some complications must be addressed promptly in order to be treated adequately, and to decrease morbidity and mortality rates. Multicentric studies should be performed, including various healthcare facilities across states, to obtain a validated model of the effect of geospatial disparities on the outcomes of orthopedic procedures.

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