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Surgical Management of Achilles Tendon Ruptures in the United States 2006-2020, an ABOS Part II Oral Examination Case List Database Study

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Abstract

Background: In correlation with a growing body of evidence regarding nonoperative management for Achilles tendon rupture (ATR), studies from Europe and Canada have displayed a decreasing incidence in surgical management, which has not been noted in the United States. The primary objective of this study is to evaluate the US trend in ATR repair volume.

Methods: The American Board of Orthopaedic Surgery (ABOS) Part II Oral Examination Case List Database was used. All cases using *Current Procedural Terminology* codes for primary ATR repair were requested from the years 2006-2020. Total submitted Achilles repair volume, the number of candidates submitting an Achilles repair case, and the overall submitted case volume per examination year was analyzed. Poisson and linear regressions were used to determine statistically significant trends.

Results: The total number of Achilles repair cases submitted for the ABOS Part II Oral Examination significantly increased from 2006 to 2011 and then decreased until 2020. Taking Achilles repair cases as a proportion of total orthopaedic cases submitted, the same trend was seen. The number of candidates submitting an Achilles repair case increased from 2006 to 2009 and then decreased until 2020. Foot and Ankle fellowship-trained candidates submitted an increasing number of ATR repair cases per candidate during the time period studied.

Conclusion: This is the first study to demonstrate a decline in the volume of ATR repair in the United States. The decline in ATR repair volume seen in the ABOS Part II Case Lists does not match previously published US surgeon practice patterns but is not necessarily generalizable to beyond this period. Although the overall ATR repair volume in the ABOS Part II Case Lists is decreasing, we found Foot and Ankle fellowship-trained surgeons are operating on an increasing number of ATRs during their board collection period.

Level of Evidence: Level III, retrospective cohort study.

Keywords: Achilles rupture, Achilles repair, ABOS, surgical management

Introduction

The Achilles tendon is the most common lower extremity tendon ruptured.[26] In the United States, the incidence of Achilles tendon rupture (ATR) ranges from 1 to 18 per 100 000 and has been increasing.[8,14,26] Middle aged (30s-40s) male recreational athletes have been shown to be at the highest risk of rupture.[11,12,14,25] Epidemiologic studies

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from Europe and Canada have also displayed an increasing incidence of ATRs, which is thought to be due to an increase in participation in recreational sports across all age groups.[10,11,13,16,27]

There is no clear consensus regarding the superiority of operative or nonoperative management for acute ATR. Traditionally, operative management was thought to be superior to nonoperative management in terms of the risk of rerupture.[18] However, up to a 12% complication rate (including wound complications, nerve injury, and rerupture) was reported after operative treatment of acute ATR.[29,34] In recent years, through randomized controlled trials and meta-analyses, early functional rehabilitation of conservatively treated ATR has shown clinical outcomes with similar return to activity, functional results, and quality of life as compared to operative management with no increased risk of rerupture.[6,15,17,21,23,28,30,33] On the contrary, other studies contest that surgical repair may offer benefits above nonoperative management such as improved postoperative calf strength or lower rerupture rates, which should be weighed in relation to the increased operative complications.[1,7,12,19,22]

The same studies in Europe and Canada that have shown an increasing incidence of ATRs have also demonstrated a decreasing incidence in the proportion of patients who receive surgical management.[10,11,13,16,27] It is hypothesized that this trend is in response to the body of evidence supporting nonoperative management. However, contemporary studies examining surgical rates for ATR in the United States have shown that the rate of surgical management is either unchanged or increasing.[6,8,32] Additionally, in the United States, up to 78% of American orthopaedic surgeons chose to treat their patients operatively after acute ATR in 2 recently reported surveys.[20,24]

There have been no recent published studies using national US data investigating Achilles tendon repair volumes, trends across patient demographics, and surgeon fellowship training, with a specific emphasis on surgeons who have recently finished formal training. The objective of this study was to investigate ATR repair volume trends in the United States in a data set that hypothetically would be more likely to correlate with recent literature. The primary hypothesis was that similar to Canada and Europe, for the data set used, the United States would also display a decrease in the number of ATRs being repaired.

Materials and Methods

Data were used from the American Board of Orthopaedic Surgery (ABOS) Part II Oral Examination Case List Database, 2006-2020. This is a national database that generally reflects 6 months of operative cases for orthopaedic surgeons in their initial years of practice immediately after fellowship training. The database was intentionally selected for its potential to reflect evidence-based practice as (1) the surgeons are fully aware that their case lists will be scrutinized for the ABOS Part II Oral Board Certification Examination and (2) the surgeons are as close as possible to their formal training. All cases using *Current Procedural Terminology* (*CPT*) codes for primary Achilles tendon repair (*CPT* 27650) and primary Achilles tendon repair with graft (*CPT* 27652) were requested from ABOS Case Lists submitted by candidates for the ABOS Part II Examination from the years 2006 to 2020. Data after the 2020 examination year was purposefully omitted to limit the impact of the COVID-19 pandemic. These data additionally included the absolute number for overall orthopaedic case volume in the case lists and the overall number of candidates per examination year. All case volume represented in the database is reported by examination year and not the year of surgery for each patient. The national incidence of ATR, the annual ATR repair volume beyond the case lists, and the volume of ATR presenting to candidates are not available in this analysis.

All patient and surgeon demographics available in the ABOS data set were analyzed including patient age, patient gender, and surgeon fellowship subspecialty. The volume of Achilles repair cases in the annual case lists would be sensitive to the changing annual number of candidates and changing annual total case volume. As such, additional analysis was performed accounting for overall orthopaedic case volume per examination year.

Achilles repair volume and the number of candidates submitting an Achilles repair case was analyzed. The same set of analyses was done by subspecialty fellowship training for Sports Medicine, Foot and Ankle, Trauma, and "Other." "Other" includes Adult Reconstruction, Spine, Hand and Upper Extremity, Pediatrics, Oncology, Shoulder and Elbow, Joint Preservation, and no subspecialty training. If a candidate had completed fellowship training in multiple subspecialities, they were included in each specialty respectively.

To perform the trend analysis, all data of interest were first graphically assessed. For all absolute volume data, a Poisson regression was used using year as the independent variable. Piecewise regressions were used based on inflection points noted in graphical analysis. When no inflection point was noted graphically, the model stayed with year as the only independent variable. When piecewise regressions were used, the model selected was based on minimizing the Akaike information criterion. When variables were transformed to evaluate trends relative to total orthopaedic case list volume or for the per candidate analysis, the same steps as above were used except with simple linear regression. A P value $<.05$ was considered significant across all statistical analyses. All statistical analyses were performed using SAS 9.4 (SAS Inc, Cary, NC).

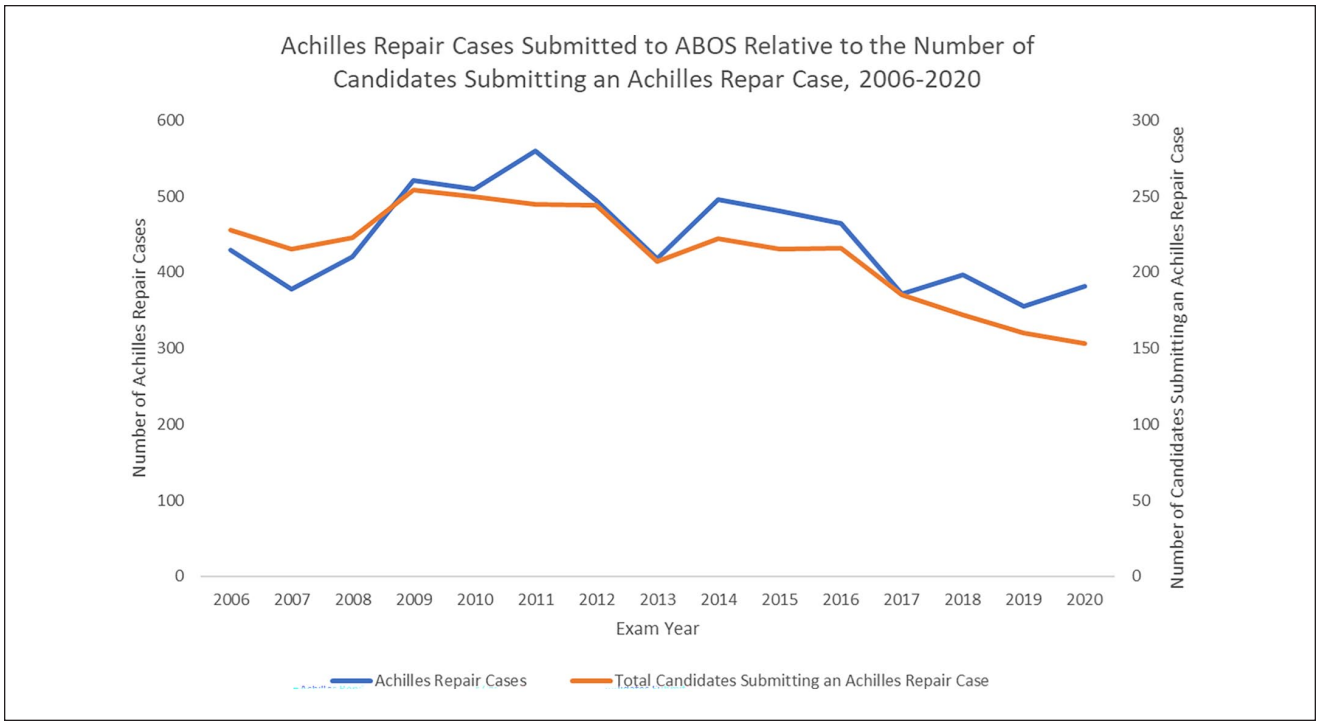

Figure 1. Comparison of the number of Achilles repair cases submitted to ABOS and the number of candidates submitting an Achilles repair case, 2006-2020.

Results

Among 10 693 total ABOS Part II Oral Examination candidates from 2006 to 2020, there were 1 292 697 orthopaedic cases submitted. The total number of orthopaedic cases submitted per year ranged from 78 681 to 90 525. The number of candidates increased over time outpacing the increase in the number of cases submitted, resulting in the number of orthopaedic cases submitted per candidate to be significantly decreasing from 2006 to 2020 with 130.8 orthopaedic cases per candidate in 2006 and 114.3 orthopaedic cases per candidate in 2020 ($P < .0001$). The average number of orthopaedic cases submitted per candidate was 121.2 (SD: 6.9).

Of the 1 292 697 orthopaedic cases submitted there were 6677 Achilles repair cases submitted to ABOS. The total number of Achilles repair cases submitted significantly increased from 429 in 2006 to 560 in 2011 ($P < .0001$) and then significantly decreased to 382 in 2020 ($P < .0001$). The maximum number of Achilles repair cases submitted in 1 year was 560 in 2011 and the minimum being 355 in 2019 (Figure 1). The number of candidates submitting an Achilles repair case increased from 228 in 2006 to 254 in 2009 ($P = .0046$) and steadily decreased to 153 in 2020 ($P < .0001$) (Figure 1).

The average patient age and gender was 40.6 years and male, with ages 30-39 years being the most common decade of life. Although there was overlap in the fellowship subspecialty, Foot and Ankle trained surgeons submitted the majority of Achilles repair cases to ABOS. Most cases were performed without grafting (*CPT* code 27650) (Table 1).

Taking the number of Achilles repair cases as a proportion of the total number of orthopaedic cases submitted, there was a statistically significant increase from 2006 (0.50%) to 2011 (0.71%) ($P = .0002$). This was followed by a statistically significant decrease in the number of Achilles repair cases as a proportion of total orthopaedic cases from 2011 (0.71%) to 2020 (0.44%) ($P = .0128$) (Figure 2).

Patients aged 30-59 years, the age group traditionally associated with ATR, mirrored the overall volume trend showing an increase in Achilles repair cases from 344 cases in 2006 to 432 cases in 2011 ($P < .0001$) followed by a downward trend to 251 cases in 2020 ($P > .0001$). Patients aged <30 years experienced a statistically significant upward trend from 53 cases in 2006 to 122 cases in 2015 ($P = .0028$) and flattened out until 2020 ($P = .6111$) (Figure 3). The Achilles volume submitted for male patients was consistent with the overall Achilles repair volume trend, peaking in 2011 at 455 cases and decreasing to 313 by 2020 ($P < .0001$). Although a small sample, the volume among female patients revealed a subtle decrease from 79 in 2006 to 69 in 2020 ($P < .0001$).

Foot and Ankle subspecialists had a statistically significant increase in Achilles repair case volume submitted to

Table 1. Patient Characteristics and Demographics Among Achilles Repair Cases Submitted to ABOS, 2006-2020 (N = 6677).

Characteristic	Mean (SD) or n (%)
Age, mean (SD)	40.6 (12.8)
Age groups, y	
<20	208 (3.1)
20-29	1046 (15.7)
30-39	2164 (32.4)
40-49	1698 (25.4)
50-59	976 (14.6)
60-69	448 (6.7)
70-79	124 (1.9)
80-89	9 (0.1)
>89	4 (0.1)
Gender, n (%)	
Female	1349 (20.2)
Male	5328 (79.8)
Fellowship Subspecialty	
Sports Medicine	2326 (34.8)
Adult Reconstruction	358 (5.4)
Spine	110 (1.7)
Trauma	540 (8.1)
Foot and Ankle	2530 (37.9)
Hand and Upper Extremity	139 (2.1)
Pediatrics	67 (1)
Shoulder and Elbow	149 (2.2)
Joint Preservation	4 (0.1)
None	943 (14.1)
CPT Code	
27650	6423 (96.2)
27652	256 (3.8)
27650 and 27652	2 (0.03)

Abbreviations: ABOS, American Board of Orthopaedic Surgery; *CPT*, *Current Procedural Terminology*.

ABOS from 109 in 2006 to 224 in 2020 ($P < .0001$) (Figure 4). The number of Foot and Ankle subspecialists increased over time from 36 in 2006 to a maximum of 60 in 2018. Of Foot and Ankle subspecialists submitting an Achilles repair case, there was a statistically significant increase in cases per candidate ($P = .0498$) (Figures 5 and 6). This analysis confirms that the volume change was not driven entirely by the increase in the number of Foot and Ankle subspecialists submitting an Achilles repair case.

Sports Medicine subspecialists had a statistically significant upward trend from 142 ATR repair cases in 2006 to 217 cases in 2011 ($P < .0001$) followed by a decreasing trend to 117 in 2020 (Figure 4). However, of Sports Medicine subspecialists submitting an Achilles repair case, there was no significant change in Achilles repair cases per candidate 2006-2020 given the trend for the number of candidates mirrored the Achilles repair volume trend ($P = .9853$) (Figures 4-6). "Other" subspecialists had a statistically significant decrease in Achilles cases from 165 cases in 2006 to 57 cases in 2020 ($P < .0001$) (Figure 4). Although the number of candidates in the "Other" subspecialty category also declined 2006-2020, there was still a slight significant decrease in Achilles repair cases relative to the number of "Other" subspecialists submitting an Achilles case ($P = .042$) (Figures 5 and 6).

Discussion

To our knowledge, this is the first study of any national US population that demonstrates a decrease in the volume in ATR repair in the time period following multiple RCTs supporting nonoperative management albeit the ABOS data set was specifically chosen suspecting a greater likelihood of this correlation.[6,15,17,21,23,28,30,33] Specifically, despite an increase in the number of ABOS candidates from 2009 to 2020, the number of candidates submitting an Achilles repair case decreased (Figure 1). In terms of a specific inflection point, the total number of Achilles repair cases submitted decreased over time after 2011 (Figure 1) and Achilles repair cases made up a decreasing proportion of total orthopaedic cases submitted after 2011 (Figure 2). The inflection in 2011 noted in our data is following the bulk of the RCTs supporting nonoperative management from 2007 to 2010.[17,21,30,33] In contrast, also within the United States, using the PearlDiver Database, Wang et al[32] found that from 2007 to 2011, of 12 570 acute ATRs, the ratio of operative to nonoperative management increased from 1.41 to 1.65, whereas Erickson et al[8] using the same database from 2005 to 2011 found no change in the percentage of ATRs treated operatively. Also in contrast, from 2007 to 2015, using the MarketScan Commercial Claims and Encounters database, Crook et al[6] found that the percentage of ATRs managed surgically remained stable ranging from 69.7% to 72.4%.

The study findings potentially represent a response among early-career US surgeons to the recent body of literature suggesting that early functional rehabilitation of nonoperatively treated ATR produces similar outcomes to operative management. Alternatively or in part, ABOS Part II examination candidates may be demonstrating only a temporary inclination to avoid a controversial topic. Regardless, the trend suggests an acknowledgement by these surgeons of recent Achilles rupture treatment literature.

This trend has already been established outside of the United States. In Canada, Sheth et al[27] found that despite an increasing incidence of ATRs, the overall surgical repair rate decreased from 20.1 in 2003 to 9.2 per 100 ATRs in 2013. In Finland, Leino et al[13] found that the surgical repair rate decreased from 13.6 to 4.9 per 100 000 person-years whereas nonoperative treatment increased from 3.7 to 27.5 per 100 000 person-years over 1997-2019. Potentially

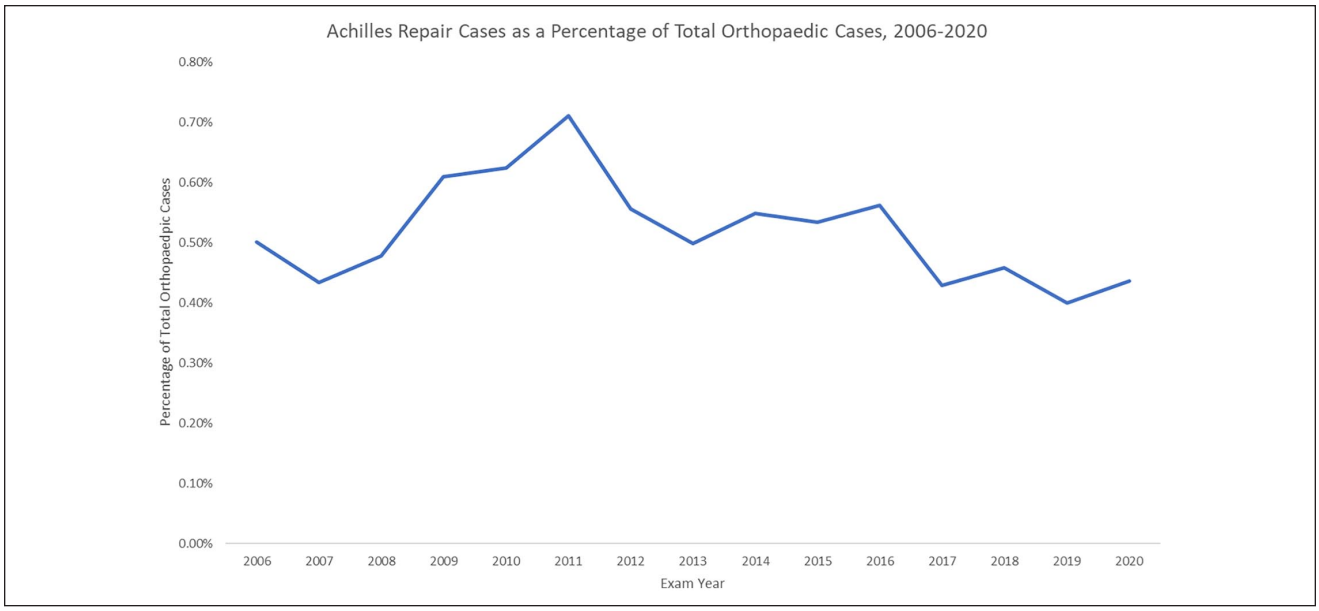

Figure 2. Achilles repair cases as a percentage of total orthopaedic cases submitted to ABOS, 2006-2020.

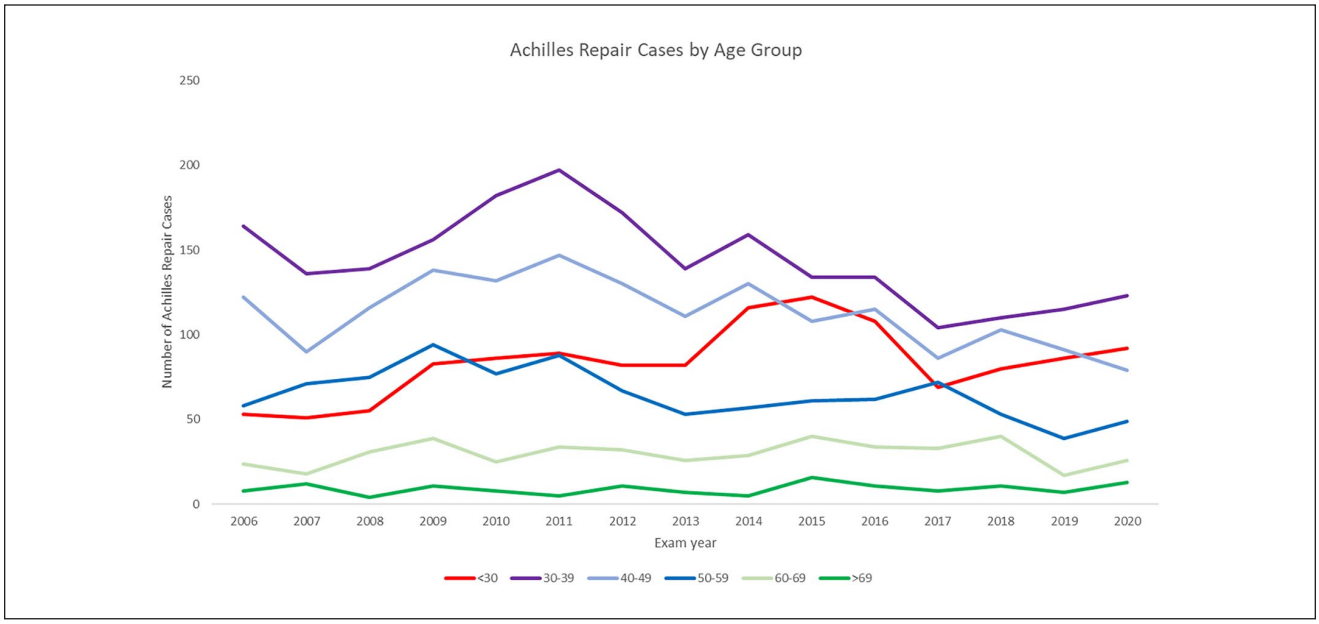

Figure 3. Achilles repair cases submitted to ABOS by age group, 2006-2020.

inciting these practice management changes are multiple randomized controlled trials and meta-analyses that provide evidence of equal outcomes among operative and nonoperative management.[4,6,15,17,21,23,28,30,31,33] Most recently, Myhrvold et al[19] performed a randomized controlled trial of 526 patients to 3 groups—minimally invasive surgery, open repair, and nonoperative treatment—and did not find any significant changes in Achilles' tendon Total Rupture Score from baseline to 12 months. However, in contrast to many other RCTs, they noted a higher rerupture rate among nonoperative care (6.2% vs 0.6% vs. 0.6%).[15,17,19,21,23,30,33] The benefit of decreased rerupture of operative treatment are supported by other studies along with reported benefits of calf strength, although many suggest this is in tradeoff with additional surgical complications such as infection and nerve injury.[1,7,12,22]

These disparities in conclusions have drawn attention to the clinical relevance and bias of the *P* value within RCTs

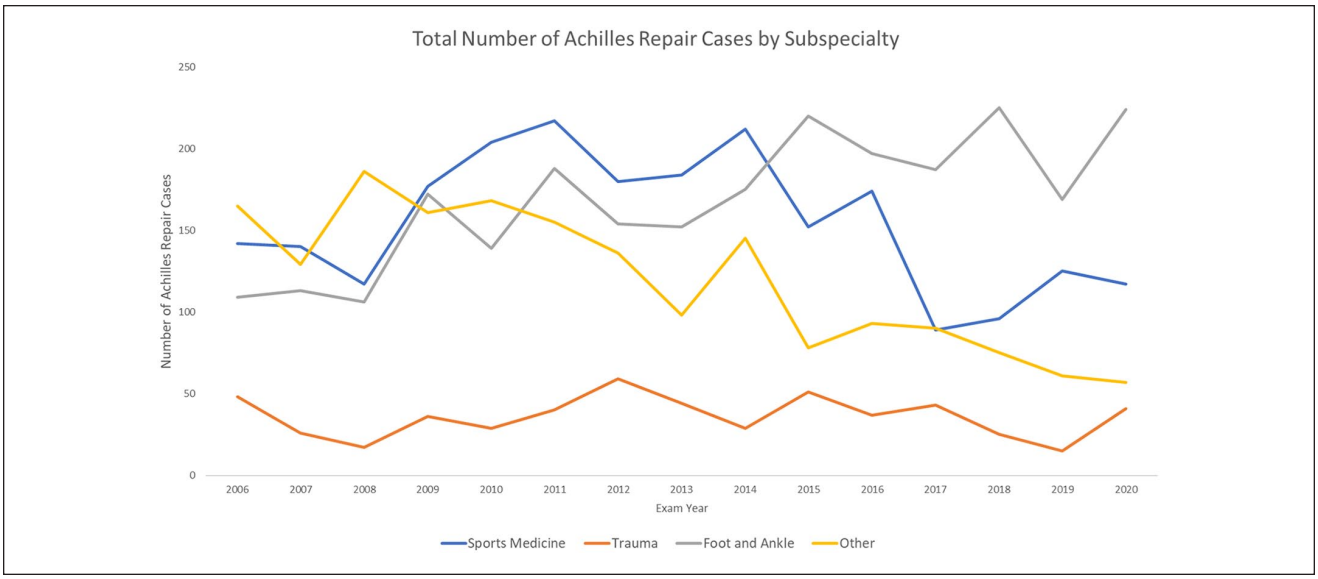

Figure 4. Number of Achilles repair cases submitted to ABOS by fellowship training, 2006-2020.

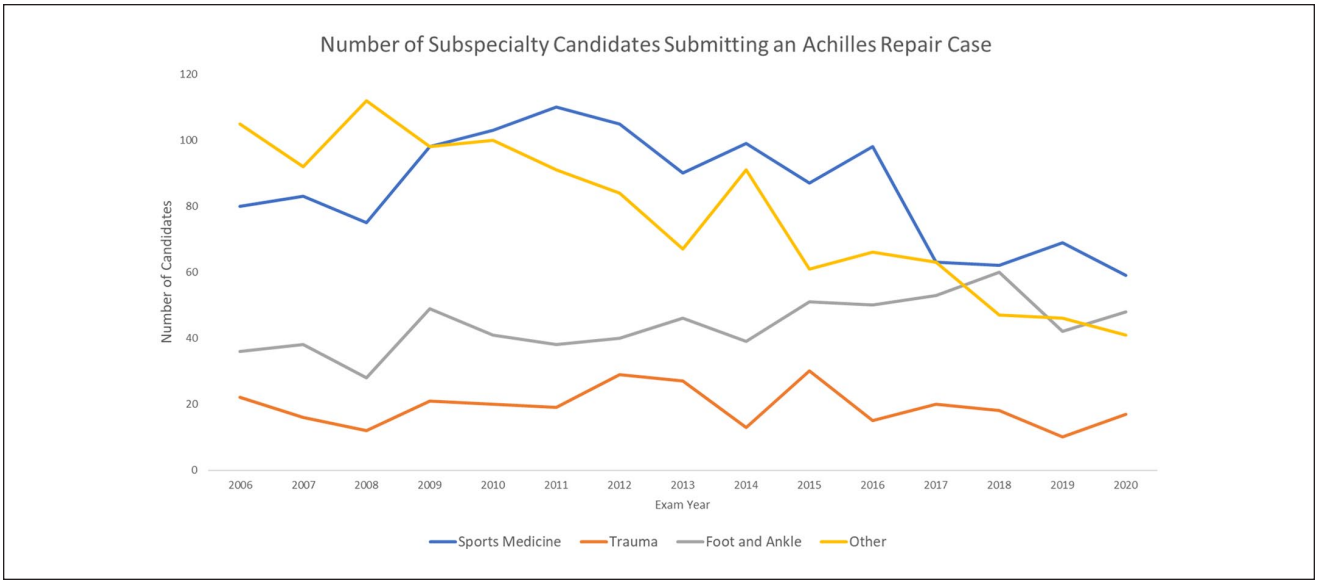

Figure 5. Number of subspeciality candidates submitting an Achilles repair case, 2006-2020.

comparing Achilles treatment management. A study by Fackler et al employed the Fragility Index (FI), which attempts to identify the number of outcomes needed to be reversed in order to change study findings from statistically significant to insignificant. Evaluating many of the RCTs cited in this manuscript, it was found that on average, only 2.9 patients (FI=2.9) needed to have outcomes reversed. Furthermore, they found 78% of studies had more than 2.9 patients lost to follow-up.[9] The previously published persistent surgical rates among US surgeons in general may be a reflection of an appreciation of the limitations of these studies. Additionally, US surgeons are not an isolated group; other countries outside of Europe such as Japan have demonstrated a rise in ATR surgical rates during 2006-2017 as well.[35]

This study demonstrated that the volume of Achilles repairs submitted increased among Foot and Ankle subspecialists. Interestingly, this volume increase outpaced the rise in the number of Foot and Ankle candidates, and each Foot and Ankle candidate is on average submitting an increasing number of Achilles repair cases (Figures 4-6). One explanation may be that referral volume may be shifting more toward subspeciality care as the next generation of orthopaedic surgeons are more likely to be subspecialists.[2] The incidence of Achilles ruptures presenting to Foot and

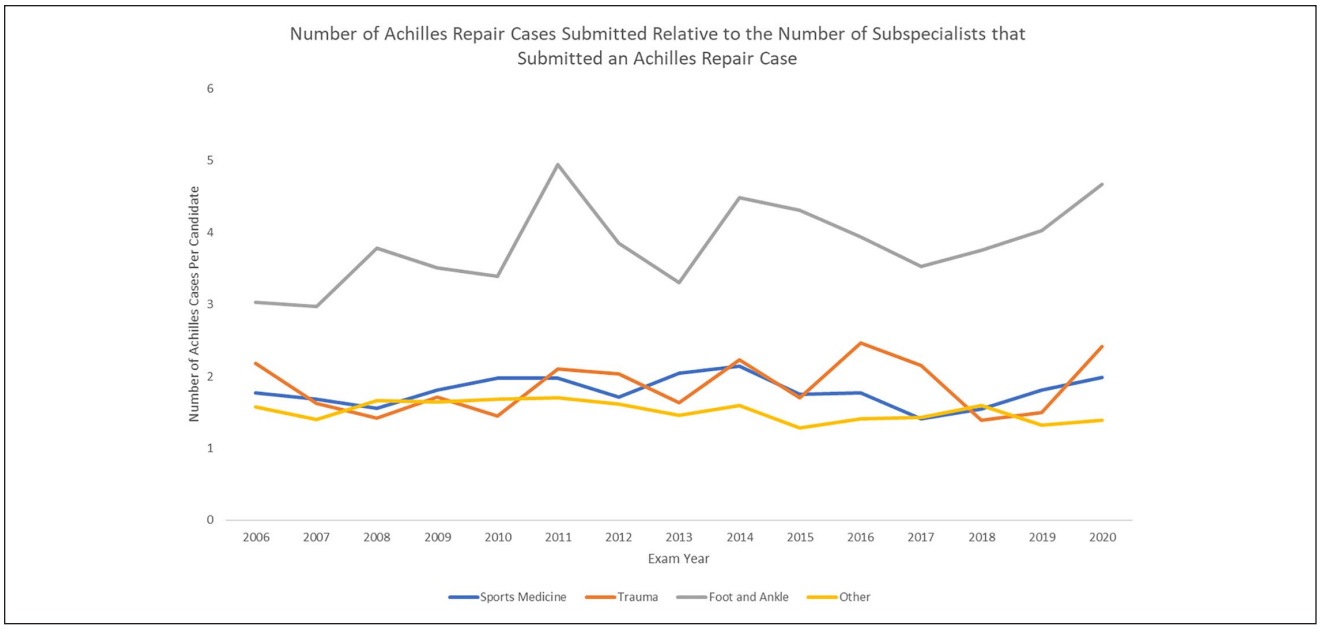

Figure 6. Number of Achilles repair cases submitted to ABOS by subspecialty fellowship training relative to the number of candidates in that fellowship submitting an Achilles repair case, 2006-2020. This figure represents Figure 4 divided by Figure 5.

Ankle–trained surgeons may be increasing via referral patterns. Foot and Ankle–trained surgeons may still be treating a growing number of ATRs nonoperatively (not captured by ABOS Part II Case Lists) along with the operatively treated ruptures demonstrated in this study. Patients presenting to the office of subspecialty care may also have a higher probability of receiving surgical treatment as a biased subset of the population seeking subspecialty care. Furthermore, with ambiguity regarding the consensus on the treatment of ATRs, it is conceivable that different fellowship-trained subspecialists have different views on optimal management and have different levels of comfort with novel techniques that are available, such as minimally invasive surgery (MIS). MIS for ATR has increased in popularity with advocates suggesting earlier functional recovery with reduced damage to adjacent tissues. However, some argue that it is a mere tradeoff of complications: although open repair increases the risk of superficial infections and ankle stiffness, MIS increases the risk of sural nerve injury and both have similar rates of rerupture.[3] Nonetheless, the RCT by Myhrvold et al[19] included a comparison of open to MIS and found no difference in outcomes at 12 months. Overall, with the currently available data on Achilles rupture treatment, Foot and Ankle–trained surgeons may have a greater comfort level in treating ruptures surgically during their board collection period than other surgeons.

In terms of patient demographics, similar to established demographics for this injury, male patients and those aged 30-59 years appeared to drive the overall changes in volume (Figures 3). A US epidemiologic study of ATR by Lemme et al[14] from 2012 to 2016 indicated that the largest rise in incidence was among ages 40-59 years. When taken into context within our study, this is further support for a declining surgical rate given the volume of ABOS Part II submission began decreasing after 2011 despite this reported increase in the incidence of ATRs. In our study, patients aged <30 years appeared to have an increase in volume until 2015 and remained flat thereafter, not demonstrating the decline seen in the older demographic. This finding is corroborated by Sheth et al[27] who showed that despite overall decreasing rates of surgery in Canada from 2003 to 2013, ages <20 years were associated with an increase in the rate of surgery. Additionally, younger age has been shown to be a predictor of better outcomes in ATR repair.[5] This perhaps biases surgeons to be more likely to offer surgical management in a young patient eager to return to athletic activity. In this study, the volume among women, although a relatively small sample size, revealed a subtle decrease throughout the study period whereas males experience a marked decrease after 2011. Among other studies, Huttunen et al[11] showed in Sweden that although males undergo surgery more often than females, both males and females underwent significant decreases in surgical rates.[27] Thus, there may be an underlying disparity in management changes in the United States with respect to patient gender although interpretation is difficult with the limited data set.

This study is not without limitations as perhaps this trend is only an indication that orthopaedic surgeons early out of training are more cautious about repairing ATRs given the recent literature, but these data may not reflect their later practice patterns. The majority of national orthopaedic case volume is among more experienced surgeons whose practice patterns are not elucidated in this study. The study also does

not take into account the total number of patients presenting to the office with an ATR and, therefore, we cannot determine the true proportion of cases undergoing surgical management. Interpreting the data of this study is also done with the assumption that the denominator of patients with ATRs has not been in some manner been increasingly directed away from early-career orthopaedic surgeons during their ABOS Part II examination case collections period.

In conclusion, this study analyzed 6677 Achilles repair cases submitted by ABOS Part II Oral Examination candidates from 2006 to 2020. Focusing on the period following increased literature supporting consideration of conservative treatment of ATRs, this is the first study to demonstrate a decline in the volume of Achilles repair in the United States from 2011 to 2020, similar to European and Canadian findings. Even in the ABOS Part II examination data set studied, Foot and Ankle trained surgeons are operating on an increasing number of ATRs, which may reflect an increasing incidence of ATRs, preferential referral patterns, and changes in surgical technique. The study findings reflect a subset of early-career practice in the United States only and do not necessarily contradict previously published general trends toward operative treatment for ATRs in the United States.

Ethical Approval

Ethical approval was not sought for the present study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. Disclosure forms for all authors are available online.

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