Original Article

Wide Variability of Pediatric Knee Arthroscopy Case Volume in Orthopaedic Surgery Residency

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Purpose: The purpose of this study was to evaluate orthopaedic surgery resident case volume and variability for adult and pediatric knee arthroscopy from 2016 to 2020. **Methods:** The Accreditation Council for Graduate Medical Education surgical case log data from 2016 to 2020 for graduating United States orthopaedic surgery residents were analyzed. The average number of total (adult and pediatric), adult, and pediatric knee arthroscopy cases were compared from 2016 to 2020. The 10th and 90th percentiles of case volumes for adult and pediatric knee arthroscopy procedures were compared from 2016 to 2020 to determine caseload variability. **Results:** There was an 18% increase in pediatric knee arthroscopy cases between 2016 and 2020 (average: 13.9 ± 10 to 16.4 ± 13; $P < .005$), a 5.4% decrease in adult knee arthroscopy cases (100 ± 45 to 94.6 ± 47; $P < .027$), and a 2.6% decrease in total knee arthroscopy (113.9 ± 47 to 111 ± 51; $P = .264$) cases. There was an 11-fold difference in the number of pediatric knee arthroscopy cases performed between the 10th and 90th percentile of residents in 2020 (3 vs 33 cases, respectively), a 3.28-fold difference for adult knee arthroscopy (47 vs 154, respectively), and a 2.98-fold difference for total knee arthroscopy (59 vs 176, respectively). **Conclusions:** Pediatric knee arthroscopy comprises a small yet growing percentage of total knee arthroscopy case volume of graduating orthopaedic surgery residents. However, wide variability in resident exposure is present and likely masked by the abundance of adult cases performed each year. **Clinical Relevance:** The findings presented in this study may assist in optimizing arthroscopy resident education. Existing ACL reconstruction and knee arthroscopy case minimum requirements could be updated to include a set number of pediatric cases. These changes might help reduce case volume variability and discrepancies in resident education.

Introduction

Major changes in orthopaedic residency education have occurred in the last decade. In 2013, the National Accreditation Society (NAS) implemented a set of clinical competency milestones in 16 orthopaedic clinical areas.[1] Semiannual assessment of a resident's medical knowledge and procedural skill within these categories is sent to the Accreditation Council for Graduate Medical Education (ACGME) and used to define program outcomes.[1] The ACGME has implemented a number of case minimum requirements within these areas to ensure residents gain adequate exposure.

Anterior cruciate ligament (ACL) and meniscus injury are pillars of orthopaedic surgery residency education and account for 2 of the 16 clinical competency milestones. While the ACGME mandates residents to perform a minimum of 30 knee arthroscopy and 10 ACL reconstruction procedures each year, no distinction between pediatric and adult cases is made. However, the surgical indications, techniques, instrumentation, and operative risks associated with these procedures vary considerably among these demographics. Therefore, it is important to view pediatric and adult knee arthroscopy as individual entities.

The purpose of this study was to evaluate orthopaedic surgery resident case volume and variability for adult and pediatric knee arthroscopy from 2016 to 2020. We hypothesize that a small but increasing percentage of

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Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received April 26, 2021; accepted August 17, 2021.

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2666-061X/21622

https://doi.org/10.1016/j.asmr.2021.08.005

Table 1. The Demographics of Orthopaedic Surgery ACGME Case Log Respondents

Year	Total Number of Residency Programs	Total Number of Residents
2016	153	705
2017	156	709
2018	154	729
2019	154	725
2020	154	724

total knee arthroscopy case volume involves the pediatric population and that widespread variability in case exposure is present.

Methods

The ACGME case log reports for graduating orthopaedic surgery residents were reviewed from 2016 to 2020. The ACGME presents national averages of several procedures within particular anatomic categories. Procedures include incision, excision, intro or removal, repair/revision/reconstruction, trauma, fracture/dislocation, manipulation, arthrodesis, amputation, arthroscopy, and other. Anatomic categories include shoulder, humerus/elbow, forearm/wrist, hand/fingers, pelvis/hip, femur/knee, leg/ankle, and foot/toes. In this study, we assessed the average number of total (adult and pediatric), adult, and pediatric knee arthroscopy cases performed per resident listed under the "femur/knee" category year over year from 2016 to 2020 in order to calculate a percent change in case volume. In addition, we compared the ratio of the average number of procedures performed by the 10th and 90th percentiles of residents to determine case volume variability.

Statistical Analysis

The mean case volumes reported per resident were compared using unpaired two-tailed *t* tests. Pearson χ^2 analysis was used to compare fold differences among the 10th and 90th percentiles of graduating residents. The level of statistical significance was designated as $P < .05$. Excel software, version 16.0 (Microsoft Corp., Redmond, WA), was used for data input and statistical tests.

Results

The total number of orthopaedic surgery residency programs was 153 (705 residents) in 2016, 156 (709 residents) in 2017, 154 (729 residents) in 2018, 154 (725 residents) in 2019, and 154 (724 residents) in 2020 (Table 1).

The average number of total knee arthroscopy procedures performed per resident was 113.9 ± 47 in 2016, which decreased to 111 ± 51 in 2020, representing a 2.6% decrease ($P = .264$) (Table 2). The average number of adult knee arthroscopy procedures performed per resident was 100 ± 45 in 2016, which decreased to 94.6 ± 47 in 2020, representing a 5.4% decrease ($P < .027$). The average number of pediatric knee arthroscopy procedures performed per resident was 13.9 ± 10 in 2016, which increased to 16.4 ± 13 in 2020, representing an 18% increase ($P < .005$). Case volume trends for each of these categories from 2016 to 2020 are depicted in Fig 1.

The average number of total knee arthroscopy cases performed by the 10th percentile and 90th percentile of residents was 64 and 170 in 2016, representing a 2.66-fold difference, compared to 59 and 176 in 2020, representing a 2.98-fold difference (Table 3). This increase in variability was not statistically significant ($P = .581$). The average number of adult knee arthroscopy cases performed by the 10th and 90th percentile of residents was 55 and 151 in 2016, representing a 2.75-fold difference, compared to 47 and 154 in 2020, representing a 3.28-fold difference. The increase in variability was not statistically significant ($P = .440$). The average number of pediatric knee arthroscopy cases performed by the 10th percent and 90th percentile of residents was 3 and 26 in 2016, representing an 8.67-fold difference, compared with 3 and 33 in 2020, representing an 11-fold difference. The increase in variability was not statistically significant ($P = .781$). Trends in fold difference for each of these categories from 2016 to 2020 are depicted in Fig 2.

Discussion

Our study revealed that resident exposure to pediatric knee arthroscopy has significantly increased over the past 5 years. However, widespread variability in case volume is present and likely masked by the abundance of adult cases performed each year.

The ACGME mandates residents to perform a minimum of 30 knee arthroscopy cases each year. This expectation has been exceeded nearly 4-fold in recent years, as residents averaged a total of 114 cases of knee arthroscopy per year from 2016 to 2020. No significant

Table 2. Mean Number of Knee Arthroscopy Procedures for Orthopaedic Surgery Residents in 2016 and 2020

Demographic	2016	2020	% Change	*P* Value
Total	113.9 ± 47 [110 to 117]	111 ± 51 [107 to 115]	−2.6%	$P = .264$
Adult	100 ± 45 [96.7 to 103]	94.6 ± 47 [91.2 to 98]	−5.4%	$P < .027$
Pediatric	13.9 ± 10 [13.2 to 14.4]	16.4 ± 13 [15.5, 17.3]	18%	$P < .005$

Data are presented as means ± SD [95% confidence interval].

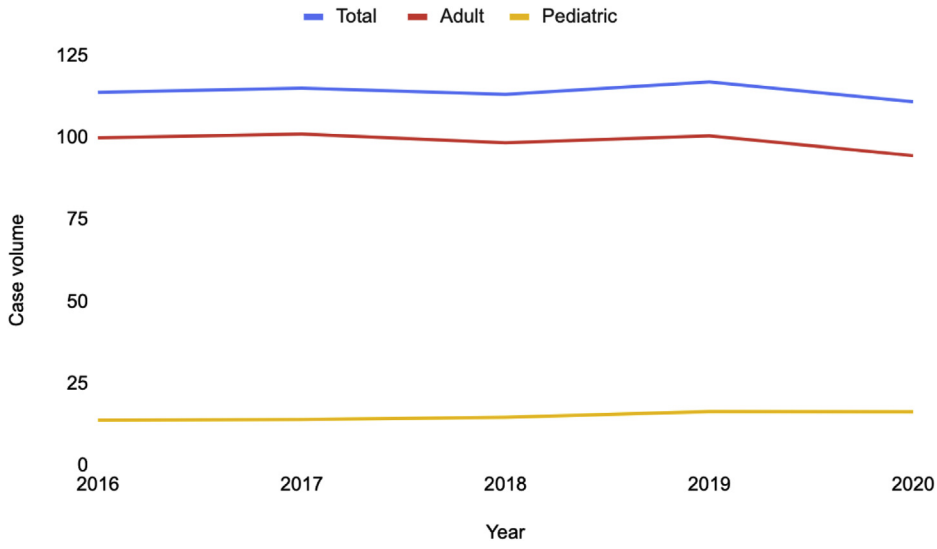

Fig 1. Trends in knee arthroscopy case volumes for graduating orthopaedic surgery residents from 2016 to 2020.

changes in case volume (114 in 2016 vs 111 in 2020; $P = .264$) or fold difference between the 10th and 90th percentiles of residents (2.66 in 2016 and 2.98 in 2020; $P = .58$) occurred during this same time period. Although these data suggest that residents have achieved an adequate case volume for knee arthroscopy in recent years, important differences arise once adult and pediatric cases are individually assessed. The mean number of pediatric knee arthroscopy cases was 16.4 in 2020, which accounted for only 15% of a resident's overall case exposure to knee arthroscopy. In comparison, the mean number of adult and total (adult and pediatric) cases was 94.6 and 111, respectively. Furthermore, wide variability in resident exposure to pediatric knee arthroscopy was present. As of 2020, an 11-fold difference in case volume between the 10th and 90th percentiles of residents existed. Case volume variability was much lower for adult cases during this time, with a fold difference of 3.28, and even lower when total (adult and pediatric) cases were assessed, with a fold difference of 2.98. Thus, low case volumes and wide variability in resident exposure to pediatric knee arthroscopy seems to be masked by the abundance of adult cases.

While the discrepancy in resident exposure to knee arthroscopy is apparent, it is unclear how this correlates with procedural proficiency. Kohring et al. studied the perceptions of recently graduated orthopaedic residents on the ability to perform common orthopaedic procedures at the end of training and on the number of cases needed to achieve independence.[2] With respect to knee arthroscopy, 96% of residents were comfortable performing meniscectomies independently, compared to 56.5% of residents for ACL reconstruction.[2] 28.8 ± 19.1 meniscectomies were recommended to achieve procedural independence, compared to 36.6 ± 21.9 ACL reconstructions.[2] However, each of these findings pertained to adult cases specifically. The only pediatric knee arthroscopy procedure studied was irrigation and debridement. Ninety eight percent of residents were comfortable with independent practice of this procedure and recommended 16.6 ± 14.2 cases to achieve competency.[2] These findings suggest that resident confidence in performing independent knee arthroscopy is dependent on procedure type and patient demographic.

We showed that resident case volume for pediatric knee arthroscopy increased 18% over the past 5 years, from 13.9 in 2016 to 16.4 in 2020 ($P < .005$), which parallels national trends in the rising incidence of pediatric knee arthroscopy.[3] Expansion of this field is developing fast, thanks to advancements in arthroscopic technology, increasing surgeon comfortability, and growing

Table 3. Fold Difference in the Average Number of Knee Arthroscopy Procedures Performed by the 10th and 90th Percentile of Orthopaedic Surgery Residents

Demographic	Year	10th	90th	Fold Difference	*P* Value
Total	2016	64	170	2.66	$P = .581$
	2020	59	176	2.98	
Adults	2016	55	151	2.75	$P = .440$
	2020	47	154	3.28	
Pediatrics	2016	3	26	8.67	$P = .781$
	2020	3	33	11	

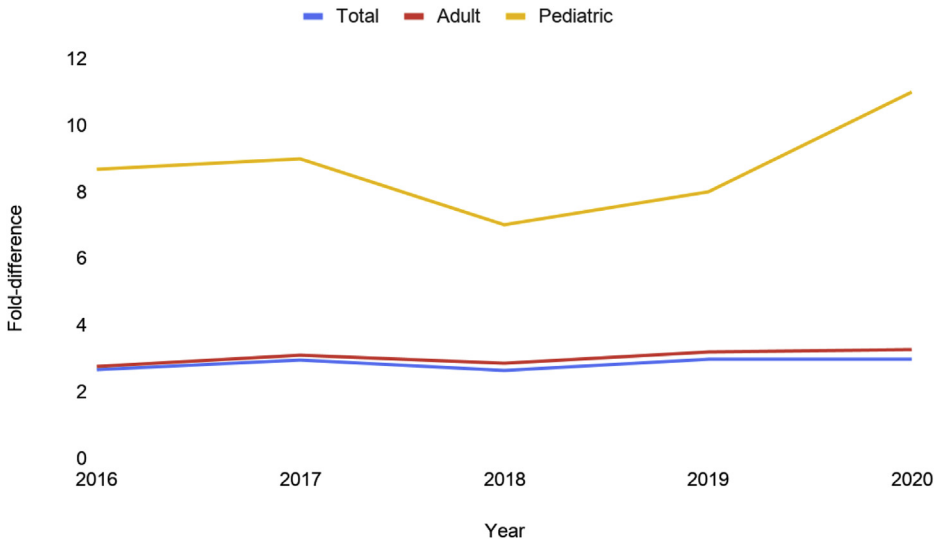

Fig 2. Trends in fold difference amongst the 10th and 90th percentile of resident-performed cases of knee arthroscopy from 2016 to 2020.

knowledge of child joint pathology.[4] While knee arthroscopy is used in children and adolescents to treat intra-articular fractures,[5] osteochondritis dissecans,[6] discoid lateral meniscus,[7] and synovitis,[8] the most common indications include sport injuries of the meniscus and ACL.[9]

The incidence of acute and overuse sport injuries in pediatric athletes is at an all-time high, given the rise in sport participation.[10] Approximately 45 million children and adolescents in the United States participate in organized sports,[10] contributing to 2.6 million emergency room visits each year for sports-related injuries.[11] In addition, increased sport specialization—defined as intensive, year-round participation in single-sport training—continues to grow in popularity,[12] as emphasis on competitive success, elite-level travel team selection, collegiate scholarships, Olympic and National team membership, and professional contracts become widespread.[13]

The knee is the most reported site of musculoskeletal injury in pediatric athletes.[9] Thus, it is no surprise that the largest application for arthroscopy in this population is the treatment of knee pathology.[3] ACL reconstruction and meniscal repair account for a large majority of pediatric knee arthroscopy cases.[9] While nonoperative or delayed surgical treatment of these injuries in the skeletally immature was once preferred to avoid physeal injury and risk of growth deformity,[14] early arthroscopic management has taken favor.[15] A recent systematic review showed excellent clinical outcomes in patients undergoing arthroscopic meniscal repair, regardless of the time from injury, location/pattern of tear, or technique used.[16] Similarly, ACL reconstruction within 12 weeks of injury is associated with a lower incidence of secondary meniscal injury and a higher rate of return to sports when compared to nonoperative management or delayed surgery.[17]

Technical differences among adult and pediatric knee arthroscopy exist and serve as important aspects of arthroscopy education for orthopaedic residents. The pediatric knee joint is smaller in size and involves neighboring growth plates, requiring adapted techniques with miniaturized equipment.[4] Gentle exposure maneuvers (valgus and varus traction) must be used to avoid iatrogenic fracture [4] and intraoperative awareness of the physes must be maintained to minimize risk of physeal arrest and limb length discrepancy.[18] Unlike adult cases, the amount of residual limb growth should be documented preoperatively for pediatric patients.[4] The proximal tibia and distal femur contribute to 6 mm and 10 mm of residual growth until the age of 13.5 in females and 15.5 in males.[19] Given these anatomic considerations, the optimal approach of certain arthroscopic knee procedures remains controversial in skeletally immature patients. In the case of ACL reconstruction, reluctance to place drill holes across open physes has led to the development of "physeal-sparing" and “partial transphyseal” reconstruction techniques.[20] Even in cases that avoid direct compromise of the physes, the graft may exert a “tenodesis effect” of tension on the growth plates.[18] Similarly, in the case of fracture fixation, hardware should spare the physes when possible and be removed expeditiously.[4]

This study revealed significant variability in pediatric knee arthroscopy cases performed by orthopaedic surgery trainees. The findings presented in this study may assist in optimizing arthroscopy resident education. Perhaps existing ACL reconstruction and knee arthroscopy case minimum requirements should be updated to include a set number of pediatric cases. These changes might help reduce case volume variability and discrepancies in resident education.

Limitations

There are several limitations of this study. First, the ACGME case log data do not specify the types of procedures (or indications of said procedures) within the knee arthroscopy category. Therefore, it was assumed that trends in case volume and variability for this generic category could be used to assume trends for specific procedure types and indications, such as arthroscopic meniscal repair and operative sport injury, respectively. Second, the accuracy of ACGME case log data has been questioned as a result of underreporting or overreporting among residents.[21] Third, the degree of resident participation within each case is subject to reporting bias, which may also threaten the accuracy of the ACGME case log data.

Conclusion

Pediatric knee arthroscopy comprises a small yet growing percentage of knee arthroscopy case volume of graduating orthopaedic surgery residents. However, wide variability in resident exposure is present and likely masked by the abundance of adult cases performed each year.

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