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AOA Critical Issues in Education

Analyses of Orthopaedic Surgery Residency Interviews

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Background: Interviews are a critical component of orthopaedic surgery residency selection for both the applicant and the program. Some institutions no longer report Alpha Omega Alpha (AOA) designation or class rank, and US Medical Licensing Examination (USMLE) Step 1 recently switched to pass/fail scoring. During the coronavirus disease 2019 (COVID-19) pandemic, all Accreditation Council for Graduate Medical Education programs conducted virtual interviews and subinternship rotations were restricted. These changes offer significant challenges to the residency match process. The purpose of this study was to examine the residency applicant interview and ranking process at a large urban academic university setting. We hypothesized that large variability exists among evaluations submitted by faculty interviewers and also that applicant academic factors (i.e., USMLE Step 1 score) would show association with final ranking.

Methods: We retrospectively reviewed the 2020-2021 and 2021-2022 residency interview cycles, both conducted virtually due to the COVID-19 pandemic. Residency application (i.e., applicant demographic and academic backgrounds) and interview data (i.e., faculty interviewer scores) were recorded. Interobserver reliability among faculty interviewers was calculated. Statistical analysis was performed to determine factors associated with ranking of applicants.

Results: There were 195 included applicants from the 2020 and 2021 interview cycles. There was no true agreement of interviewers' scoring of shared applicants (kappa intraclass coefficient range 0-0.2). Applicant factors associated with being ranked include applying to the match for the first time, USMLE Step 1 and 2 scores, educational break (vs. consecutive completion of college and medical school in 4 years each), higher class rank, and greater interviewer scores. Factors associated with better rank included additional degrees (i.e., PhD or MBA), couples match, AOA designation, educational break, underrepresented minority status, and notable attributes (i.e., collegiate athletics or Eagle Scout participation). Factors associated with worse rank included male sex, international medical graduate, prior match history, science major, extended research (i.e., >1 year spent in a research role), and home medical school students.

Conclusions: There was significant variability and no reliability at our institution among faculty interviewers' applicant ratings. Being ranked was based more on academic record and interview performance while final rank number seemed based on applicant qualities. The removal of merit-based objective applicant measurements offers challenges to optimal residency applicant and program match.

Level of Evidence: III (retrospective cohort study)

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJSOA/A465).

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Introduction

In selection of orthopaedic surgery residents, the interview is a critical component for the applicant and the training program[1,2]. Previous studies attempted to identify predictors of success both in residency and in practice at the time of residency application and interview/ranking process[3-6]. Some of these previously identified factors include US Medical Licensing Examination (USMLE) scores correlating with in-training scores and surgical skills and medical school honors grades correlating with higher overall performance, interpersonal skills, knowledge, and surgical skills[3-6]. Poor-performing residents were notably difficult to predict[4]. However, there is a dearth of research on the applicant interview and ranking process. Anecdotal experience suggests significant variability in faculty and resident evaluations of applicants.

As of January 2022, the USMLE converted the Step 1 examination to pass/fail scoring, eliminating a key historical objective measure for students applying to orthopaedic surgery residency[7,8]. Because of the coronavirus disease 2019 (COVID-19) pandemic, residency programs conducted interviews virtually during the 2020-2022 application cycles and subinternships were canceled or limited, despite record application numbers[9]. Many medical schools have also changed the information they report to residency programs such as using pass-fail grades, elimination of class rank, and variable use of Alpha Omega Alpha (AOA) designation because of concern of ethnic and socioeconomic biases[10,11]. These developments offer significant challenges and changes to the residency candidate evaluation process and may place more weight on the interview. Contemporizing the interview process to minimize bias becomes more paramount given these changes[5].

Therefore, this study sought to characterize the residency applicant interview and ranking process at a large urban academic university setting. We hypothesized that large variability exists among faculty interviewers' evaluations, and key applicant academic data were factors associated with final ranking.

Materials and Methods

Study Design

Per *STROBE* guidelines[12], data were collected from orthopaedic surgery residency interviews at our institution from December 2020 to December 2021. Applicants consented to the use of their Electronic Residency Application Service (ERAS) application data for residency program research purposes. This study was also given exemption status by the institutional review board (IRB Control #21E.454). Included applicants were at least 18 years and deidentified. Applicants with inadequate applicant interview data were excluded.

Institutional Interview Process

Screening of ERAS applications was conducted by the program's postgraduate year 5 orthopaedic residents, the program director (PD), and senior faculty. This process identifies approximately 100 qualified applicants to interview of approximately 1,000 applicants each year. This initial review of applicants was not analyzed within this study. Applicants who rotated as subinterns were given a consensus grade by residents during a separate review session. On interview days, each applicant had 3 interviews with faculty and chief residents, as well as a group interview with the PD and chairman. Interviews were conducted virtually for the first time at our institution in 2020 and 2021 due to the COVID-19 pandemic. Each interviewer graded the applicant on an 8-point scale from A1 to D and ranked all of the applicants they interviewed. Individual applicant grades and ranks were converted to a 100-point scale and averaged to a "score." An additional score was generated for each applicant by a committee meeting of all faculty/chief resident interviewers of a given applicant after interviews occurred and individual interviewer scores were generated. Faculty and PD/chairman interview scores were averaged to a final combined score used as a guide in generating a final rank list (Fig. 1).

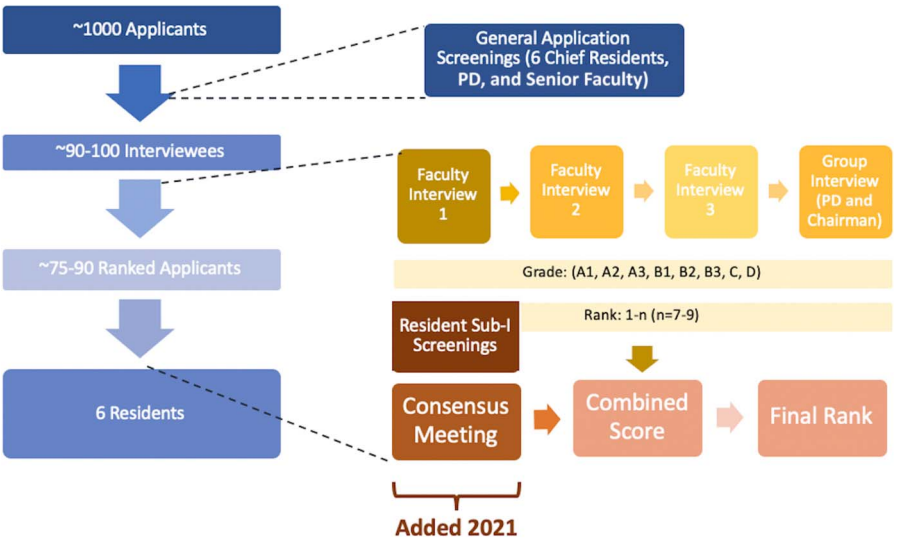

Fig. 1

Diagram summarizing the annual orthopaedic resident interview and scoring process at our institution. PD = program director.

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Data Abstraction

Abstracted demographic data included sex, underrepresented minority (URM) status, years since finishing their undergraduate education, geographical distances of applicant hometown and medical school from our program, other degrees (i.e., PhD, MBA), prior match history, couples match, international medical graduate (IMG) status, notable attribute(s), and subinternship participation. Notable attributes were subjectively recorded and consisted of unique attributes or life experiences, that is, college athletics and Eagle Scout. The following academic data were collected: USMLE Step 1 and 2 scores, educational breaks (i.e., before/during medical school), extended research (i.e., >1 year spent in a research role), postbaccalaureate (postbac), major, home student, and US News and World Report undergraduate and medical school rank. Interview scores were evaluated also including faculty/chief resident score, PD/chairman score, consensus resident scores for rotators, and combined mean scores.

Statistical Methods

Our departmental biostatistician performed all statistics. Advanced statistical analyses included bivariate Poisson regression and multivariate stepwise Poisson regression to identify final rank number predictors. For power analysis, this was a pilot study of natural history and sample size was one of convenience. Significance was determined at p value <0.05. All statistical analyses were performed using R Studio (version 4.1.2).

Results

Cohort

Ninety-nine applicants were interviewed in the 2020-2021 cycle and 102 applicants were interviewed in 2021 to 2022 for a total of 201 applicants. Six applicants from the 2020-2021 cycle were excluded from the study because of interviews conducted separately from the standard protocol, providing 195 included applicants for the study.

The application cycle cohorts were statistically similar. Differences from 2020 to 2021 included greater medical school class rank (73.5 ± 21.7 in 2021, 54.2 ± 23.6 percentile in 2020, p = 0.002); fewer applicants with notable attributes (22.5% vs. 72.0%, p < 0.001); and improved interview performance for mean interviewer scores, PD/chairman scores, and combined scores (p < 0.001). There were 20% more applications received between years and an increase in interviewing faculty (16 in 2020, 31 in 2021).

Interviewer Inter-Rater Reliability

There was no true agreement between interviewers for both grade and rank in both application years with intraclass coefficient value ranges between 0.0 and 0.2.

Predictors of Applicant being Ranked vs. Unranked

Applicant demographic, academic, and interview variables were compared among those ultimately ranked or not ranked. For applicant demographics (Table I), the only statistically significant variable was applicants with previous unsuccessful match to orthopaedic surgery were less likely to be ranked (p = 0.023). For applicant academics and interview scores (Table II), USMLE Step 1 (p = 0.005) and Step 2 (p = 0.004) scores, number of textbook chapters published (p = 0.033), educational breaks (p = 0.024), class rank percentiles (p = 0.002), and all interviewer score types (p < 0.001) were statistically significantly greater in ranked applicants.

Predictors of Applicant Final Rank

Bivariate correlations between all continuous variables and final rank number were performed. All interviewer scores

TABLE I Applicant Demographics*

Variable	Combined (n = 195)	Not Ranked (n = 31)	Ranked (n = 164)	p Value
Prior match, n (%)	8 (4.1)	4 (12.9)	4 (2.44)	0.023†
Male sex, n (%)	147 (75.4)	26 (83.9)	121 (73.8)	0.333
URM, n (%)	49 (25.1)	9 (30.0)	40 (25.0)	0.729
Mean years since undergrad, mean ± SD (range)	5.75 ± 2.07 (0-18)	6.26 ± 3.61	5.65 ± 1.62	0.362
Mean home distance (km), mean ± SD (range)	946.6 ± 1,088.2 (0-4,052.3)	1,099.2 ± 1,308.4	1,432.32 ± 2,018.1	0.246
Mean medical school distance (km), mean ± SD (range)	836.7 ± 1,306.6 (0-9,150.6)	1,247.2 ± 1,947.3	939.9 ± 1,693.0	0.415
Other degrees, n (%)	36 (18.5)	6 (19.4)	30 (18.3)	1.000
Couples match, n (%)	11 (5.6)	2 (6.45)	9 (5.49)	0.688
IMG, n (%)	5 (2.6)	1 (3.23)	4 (2.44)	0.583
Subinternship participation, n (%)	28 (14.4)	0 (0.00)	28 (31.1)	N/A

*IMG = international medical graduate, N/A = not available, and URM = underrepresented minority. †Statistically significant.

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TABLE II Applicant Academics and Interview Scores*

Variable	Combined (n = 195)	Not Ranked (n = 31)	Ranked (n = 164)	p Value
USMLEs				
Step 1 score	248.3 ± 12.1 (205-274)	240 (17.6)	250 (10.1)	0.005†
Step 2 score	256.7 ± 12.4 (217-280)	249 (13.9)	258 (11.5)	0.004†
Step 2 available	148/195 (75.9)	26 (83.9)	122 (74.4)	0.367
Research experience				
Chapters	0.3 ± 1.1 (0-8)	0.10 (0.40)	0.35 (1.18)	0.033†
Submissions	6.9 ± 8.0 (0-44)	5.67 (6.20)	7.17 (8.29)	0.280
Publications	7.9 ± 10.0 (0-69)	5.90 (8.75)	8.33 (10.2)	0.175
Posters	9.5 ± 10.8 (0-55)	8.13 (9.88)	9.71 (11.0)	0.426
Podiums	5.8 ± 9.1 (0-44)	4.55 (7.78)	6.09 (9.37)	0.335
Extended research	48/195 (24.6)	5 (16.1)	43 (26.2)	0.333
Medical school background				
Education break	146/195 (74.9)	18 (58.1)	128 (79.0)	0.024†
Class rank percentile	75.1 ± 19.9 (10-99)	54.2 (23.6)	79.4 (16.0)	0.002†
AOA	57/195 (29.2)	5 (16.1)	52 (31.7)	0.183
Home student	34/195 (17.4)	9 (29.0)	25 (15.2)	0.110
Med school US News & World Report research rank	39.5 ± 24.8 (1-93)	43.9 (25.2)	38.8 (24.7)	0.339
Med school US News & World Report primary care rank	53.8 ± 25.3 (2-93)	52.5 (26.5)	54.0 (25.1)	0.788
Other background				
Science major	172/195 (23)	27 (87.1)	145 (88.4)	0.767
Notable attribute	90/195 (46.2)	12 (38.7)	78 (47.6)	0.478
Postbac	15/195 (7.7)	3 (9.68)	12 (7.32)	0.712
Undergrad US News & World Report rank	59.7 ± 96.9 (1-1,068)	104 (190)	51.1 (62.8)	0.135
Interview performance				
Mean interviewer score	45.9 ± 17.7 (11.7-91.0)	65.8 (14.0)	43.6 (16.6)	<0.001†
Mean PD/chairman score	47.2 ± 25.9 (10.3-100)	79.2 (21.3)	43.5 (23.8)	<0.001†
Combined score	46.4 ± 19.6 (11.6-95.5)	72.5 (14.1)	43.4 (17.9)	<0.001†

*AOA = Alpha Omega Alpha, PD = program director, and USMLE = United States Medical Licensing Examination. †Statistically significant.

showed statistically significant correlation (Table III). Multivariate Poisson regression analyses showed the relative risk of a variable on final rank number (Table IV). Applicants with other degrees, couples match, AOA designation, educational breaks, notable attributes, URM status, and greater years since graduating college had higher match likelihood (lower rank). Conversely, male sex, IMG, prior match history, undergraduate science majors, extended research, and home students were associated with lower match likelihood (higher rank). Applicants with extended research experience had statistically greater number of research publications (7.0 ± 5.8) and submissions (10.0 ± 7.7) vs. those without (4.7 ± 4.7, 3.9 ± 4.3; $p = 0.021$, $p < 0.001$, respectively). Applicants with extended research otherwise did not differ in class rank, USMLE Step 1 and 2 scores, AOA designation, research posters/podiums, or undergraduate and medical school US News & World Report ranking.

Discussion

Overall, this study presents residency interview analyses over 2 years at our large academic institution, when pivotal changes faced the orthopaedic surgery resident selection process nationwide. Our hypothesis that significant variability existed in faculty interview evaluations was affirmed. Our hypothesis on which specific factors were related to final rank was partially affirmed. Orthopaedic surgery is one of the most competitive medical specialties, with 100% of 875 positions filled in 2022, leaving 852 applicants (49.3%) unmatched[13]. The mean number of applications submitted per applicant to programs increased by 72%, from 48 in 2006 to 83 in 2017. Similarly, mean total applications received per program have increased 46.4%, from 457 in 2010 to 669 in 2017. As a result, estimated in-depth reviews (subjectively defined as thorough review of all application components in a survey of PDs) of

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TABLE III Interview Score Correlation Results with Final Rank Number*

Interview score	Correlation	p Value
Mean interviewer score (2020)	0.780	<0.001
Mean interviewer score (2021)	0.757	<0.001
Mean PD score (2020)	0.460	<0.001
Mean PD score (2021)	0.780	<0.001
Mean combined score (2020)	0.715	<0.001
Mean combined score (2021)	0.977	<0.001
Mean resident score (2021)	0.863	<0.001
Mean committee score (2021)	0.860	<0.001

*PD = program director.

applicants decreased to only 45% of applications in 2016[14]. Some medical schools have switched to pass/fail grades and discarded class rank and honors societies. National changes have occurred including the transition of USMLE Step 1 scores to pass/fail and the loss of most in-person interactions during the COVID-19 pandemic.

In our study, being ranked was more based on academic factors such as USMLE Step 1 and 2 scores and class rank. Whether the USMLE Step 2 score was available did not have bearing on rank likelihood. Demographics were equivalent between ranked and unranked applicants, except those with prior match participation, which could reflect reasons for the original failure to match. Studies have highlighted the lower match likelihood facing repeat applicants when compared with first-time applicants[15,16].

Greater class rank signifies an applicant's academic competitiveness relative to their own medical school class. The nature of educational breaks (i.e., years spent out of medical training before or during medical school) was variable but ranged from nonmedical former careers to military service. This time away may give applicants a more enriched background and life experience applicable to residency training or patient care. When compared with national averages of matched applicants in orthopaedic surgery, our institution's ranked applicants had higher USMLE Step 1 and 2 scores, research experiences, AOA designation, PhD or other degrees, and notable attributes including work/volunteer experiences[13]. Interestingly, once reaching the interview, factors traditionally believed to be as important, including research publications and subinternships, did not relate to rank likelihood. Notably, the overall number of rotating students was decreased from previous years due to COVID-19 restrictions; therefore, this result may be limited because of the current period while COVID-19 restrictions are in place.

Interestingly, our results showed poor interviewer interreliability and no true agreement, yet interview scores still heavily correlated with final rank. This highlights a potential for bias and an important area for attention. Legato et al. similarly reported that the interview correlated with final rank

TABLE IV Multivariate Regression Identifying Final Rank Predictors*

Variable	Relative Risk	95% Confidence Interval
Factors associated with lower final rank (greater match likelihood)		
Any other degrees	0.73	0.68-0.79
MBA degree	0.68	0.60-0.79
Couples match	0.48	0.41-0.55
AOA	0.68	0.65-0.72
Education break	0.87	0.82-0.92
Postbaccalaureate	0.78	0.71-0.86
Notable attribute	0.86	0.85-0.95
Research chapters	0.97	0.95-0.99
URM	0.87	0.82-0.92
Greater years since undergraduate	0.95	0.93-0.96
Factors associated with higher final rank (lesser match likelihood)		
Male sex	1.31	1.24-1.39
IMG	1.54	1.36-1.74
Prior match history	1.60	1.41-1.80
Science major	1.45	1.34-1.59
Extended research experience	1.27	1.20-1.33
Home student	1.22	1.15-1.30
Factors showing no association with final rank (not predictive of match likelihood)		
Medical school distance	1.00	0.99-1.0
Home distance	1.00	1.0
Mean interview score	1.03	1.02-1.03
Mean PD/chair score	1.02	1.01-1.03
Combined interview score	1.03	1.02-1.03
Undergraduate US News & World Report rank	1.00	1.0
Medical school US News & World Report rank	1.00	1.0
USMLE Step 1 score	0.99	0.99-1.0
USMLE Step 2 score	0.99	0.99-1.0
USMLE Step 2 available	0.98	0.93-1.04
Submissions	0.99	0.99
Publications	0.99	0.99
Class rank percentile	0.98	0.98-0.99
Posters	0.99	0.98-0.99
Podiums	0.99	0.98-0.99
PhD degree	0.92	0.77-1.07
MPH degree	0.94	0.80-1.10

*AOA = Alpha Omega Alpha, IMG = international medical graduate, PD = program director, URM = underrepresented minority, USMLE = United States Medical Licensing Examination.

list order and that inter-rater reliability among faculty members was low for the applicant scoring process[2]. In our study, resident and committee scores showed higher correlation with final rank, suggesting possible greater weight to these scores (relative to PD/chairman score). Resident scores may reflect "program fit" from unique prolonged applicant interaction both clinically and socially. Postinterview committee consensus scores may facilitate greater discussion and less biased reflection of applicants, vs. a single interviewer's first impression.

Final rank number in our study appeared based on applicant characteristics including multiple degrees, educational breaks, and notable attributes. Other studies have attempted to ascertain what applicant factors are associated with successful residents. Fryer et al. found that USMLE scores were predictive of in-training scores only, and raw objective performance scores were more predictive of later performance than faculty-biased scores. The authors also concluded that poor-performing residents were notably difficult to predict[4]. The extensive review by Egol and Zuckerman on resident selection reported that high USMLE Step 1 scores correlated with higher Orthopaedic In-Training Examination scores and surgical skills during residency while honors grades correlated with overall performance, interpersonal and surgical skills, and knowledge[3]. In a study of Canadian orthopaedic residency programs, work ethics, interpersonal qualities, orthopaedic experience, and enthusiasm correlated most with final rank order. They also found that agreement across programs was poor[5].

Having other degrees, couples matching, AOA designation, taking an educational break, notable attributes, publishing textbook chapters, and greater years since graduating college all increased match likelihood in our study and may serve as markers of applicant maturity. Interestingly, objective measures traditionally believed to be very important for match likelihood, such as geographical origin, interview performance, class rank, USMLE Step 1 and 2 scores, and research accolades, had no bearing on final rank/match likelihood. IMG applicants were rare overall but associated with decreased match likelihood, consistent with other literature[3]. More historically common applicant factors, such as male sex, extended research, home institution, and undergraduate science major, were associated with a lower match likelihood, reflecting an effort to diversify the residency program.

Along these lines, our study showed that URM and female applicants were associated with greater match likelihood. While women constitute approximately 49% of the US workforce, a recent American Academy of Orthopaedic Surgeons (AAOS) article reports that only 6.5% of practicing orthopaedic surgeons and 14.8% of candidate AAOS members (resident/fellow trainees) are women[17]. Minorities constitute over 30% of the US population, yet represent only 6% of US physicians. Numbers are among the lowest in orthopaedic surgery, but have increased between 0.5% and 1.4% over the past decade[18]. Increased diversity in the field is imperative toward improving patient satisfaction and addressing healthcare inequalities. Female and URM applicants made up 25% of our respective applicant pool and were ranked with greater match likelihood. However, there is still improvement to be made, and successfully matching these applicants may require focused recruitment effort and faculty/resident representation. Target pipeline curricula such as summer internships or musculoskeletal rotations in medical school (or earlier) have shown promise in increasing numbers of diverse applicants[18].

USMLE scores, AOA designation, research, and volunteer experiences have been cited as other reasons for the disparity[19-21]. Eliminating these application factors may come from noble intent but could have negative consequences. In a survey of 78 orthopaedic surgery PDs, 59% responded that USMLE Step 2 Clinical Knowledge score will be most important after Step 1 transitions to pass/fail, and 90% will encourage applicants to include it in their application[8]. Pass/fail grading could merely increase applicant stress surrounding USMLE Step 2, with fewer opportunities to demonstrate academic performance. Students from schools with lesser known or nonexistent orthopaedic departments may face greater challenges, if programs weigh remaining application factors more heavily, such as recommendation letters and school reputation. Perhaps limiting the number of resident applications overall, as other medical specialties have done, could increase programs' ability to more closely review all applicants[14]. Future studies must examine the "preference signal" system initiated for the 2022-2023 orthopaedic surgery residency application cycle by the American Orthopaedic Association Council of Orthopaedic Residency Directors[22].

Other potential solutions for the interview process include increasing the number of interviewers for a given applicant or incorporating personality tests to account for bias[1]. Many business corporations have used questionnaires identifying personal characteristics important for success, such as ambition, humility, and curiosity, during the hiring process[7]. Motor tasks have not been shown to correlate with later resident performance or operative ability, although they do improve over time when measured throughout training[23-25]. Athletic or musical talents correlate poorly with operative ability, despite historically favorable bias[8].

This study also represents the first virtual interviews conducted at our institution due to the COVID-19 pandemic. A recent survey of applicants and PDs found that virtual experiences did not adequately replicate the social factors that applicants found most important when ranking a program, such as perception of resident happiness/camaraderie[26]. In another survey, PDs reported less ability to determine applicant fit; clinical, social, and surgical skills; and genuine interest while greater importance was placed on research. Most candidates (81%) and PDs (79%) preferred in-person interviews, despite cost savings for both[27]. Future studies at our institution must analyze the effect of virtual interview processes.

Strengths of this study include a large series of consecutive data over 2 years at a strong orthopaedic academic center, whereas limitations are that the data presented may be institution-specific. Another potential limitation of this study is selection bias because only applicants invited to interview were analyzed. The initial screening of applications to invite for interview was not assessed but should be further examined in future studies.

In conclusion, there was significant variability and poor reliability at our institution among faculty interviewers' applicant ratings. Being ranked at all was based more on academic record and interview performance while final rank number seemed based on applicant qualities. We hope this study can help optimize the resident interview and selection process to be more objective, reliable, and diverse while facilitating discussion among orthopaedic residency programs on current and future challenges.

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