Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.JournalofSurgicalResearch.com

Trends in Integrated Plastic Surgery Applicant, Resident, and Junior Attending Research Productivity

Sanjay K.A. Jinka, BS,[a] *Benjamin A. Sarac, MD,*[b] *Austin P. Seaman, MD,*[b] *Samantha L. Fry, BS,*[b] *Maria T. Huayllani, MD,*[b] *and Jeffrey E. Janis, MD, FACS*[b,*]

[a] *College of Medicine, Northeast Ohio Medical University, Rootstown, Ohio*

[b] *Department of Plastic and Reconstructive Surgery, Ohio State University Wexner Medical Center, Columbus, Ohio*

ARTICLE INFO

Article history:
Received 27 May 2022
Received in revised form
14 November 2022
Accepted 24 December 2022
Available online 18 January 2023

Keywords:
Fellowship
Integrated plastic surgery
Medical school
Publications
Research productivity
Residency

ABSTRACT

Introduction: Research productivity is critical for matching into integrated plastic surgery residency. This study will identify how pre and intraresidency research productivity correlate with resident/junior attending productivity.

Materials and methods: Retrospective review from 2006 to 2015 issues of the American Board of Plastic Surgery's Annual Newsletter to Diplomates was performed to identify newly board certified plastic surgeons. Only surgeons from US medical schools matching directly into integrated programs were included. Residency type/length, graduation year from medical school, and publication counts were recorded for each surgeon. Publications were categorized as preresidency, intraresidency, and junior attending (6 y post residency/fellowship training).

Results: Six hundred fifty-five integrated plastic surgery graduates were analyzed. The median number of total publications (preresidency, intraresidency, and junior attending) was 4 (interquartile range [IQR], 1 to 10). Linear regression revealed negligible correlation between preresidency and junior attending publications ($r = 0.019$, $P = 0.002$). Total publications and increasing graduation y had a significant correlation of 0.89 ($P < 0.001$). Graduates of fellowships had significantly increased median total publications compared to those without fellowships (7 IQR, 3 to 18 *versus* 3 IQR, 1 to 7, respectively, $P < 0.001$). Dedicated research years during residency were associated with significant ($P < 0.001$) increases in median total and junior attending publications. Total publications ranged from 3 (IQR, 1 to 6) to 8 (IQR, 7 to 18) for those who completed 5- and 8-y residencies, respectively.

Conclusions: Increased preresidency research productivity is not strongly associated with increased junior attending productivity in integrated plastic surgery. Better markers are completing dedicated research years in residency or fellowship after residency.

* *Corresponding author*. Ohio State University Wexner Medical Center, 915 Olentangy River Road, Suite 2100, Columbus, OH 43212.
E-mail address: Jeffrey.Janis@osumc.edu (J.E. Janis).

0022-4804/$ – see front matter © 2023 Elsevier Inc. All rights reserved.
https://doi.org/10.1016/j.jss.2022.12.025

Introduction

Integrated plastic surgery is one of the most competitive categorical residencies.[1] A chief component for selection into an integrated plastic surgery residency is research productivity.[2,3] Integrated plastic surgery has the second highest research productivity after neurosurgery according to the National Residency Matching Program (NRMP), suggesting the importance of research for successful matching.[4] Further, research productivity is only growing with time. In 2020, successfully matched applicants to integrated programs had 5.9 mean research experiences and 19.1 abstracts, presentations, and publications.[4] This is up from only 3.4 abstracts, presentations, and publications for matched applicants in 2007.[2,3]

Residency program interest in research stems from many factors, including demonstration of initiative, critical thinking, and passion for the chosen field.[5] Research productivity during residency can also bring institutions grant funding and advance the specialty.[6] Further, research productivity provides the opportunity to forge meaningful relationships and leads to better exposure between the mentor and mentee than a single interview day or even a month-long rotation.[7-10]

To date, no research has been performed exploring whether preresidency research productivity leads to resident and attending productivity after completing an integrated plastic surgery residency. This study aims to fill this void and analyze research productivity of plastic surgeons during preresidency, intraresidency, and as a junior attending time periods to evaluate whether early-attending research productivity is correlated with productivity in earlier years of training. Further, this study will analyze what factors within residency including the decision to pursue a fellowship and take intraresidency research years have on productivity.

Materials and Methods

Procurement of integrated plastic surgery graduates

A retrospective review of the "New Board Diplomates" list found in The American Board of Plastic Surgery's *Annual Newsletter to Diplomates* from 2006 to 2015 was conducted to identify board certified plastic surgery residency graduates.[11]

The training history of each surgeon was obtained from Doximity, LinkedIn, or physician practice websites to determine the year of graduation from medical school and type of plastic surgery residency program they attended. The inclusion criteria consisted of US integrated plastic surgery residency graduates practicing in the United States. Medical graduates who took transitional/preliminary or gap years after completing medical school were excluded to control confounding variables that may affect research productivity.

Each integrated plastic surgery graduate's year of medical school completion, length of integrated residency (5-6 y or 7-8 with research years), and decision to pursue a fellowship/type of fellowship, were recorded.

Determination of research productivity

The free online "iCite" tool from the National Institutes of Health, Office of Portfolio Analysis, was used to determine the number of publications for each surgeon.[12] All iCite search results were manually reviewed. Author's middle initials were included when searching to further improve accuracy and clarity in terms of proper author/publication attribution.

Publications were categorized as pre-residency, intra-residency, and junior attending publications. Pre-residency publications included all publications dated until 1 y after residency began. Intra-residency publications included those published from the second year of residency until 1 y after completion of residency. Junior attending publications included those published over the subsequent 6 y following completion of residency or fellowship training (whichever was later). This 6-y cutoff was chosen to allow surgeons' junior attending publications to be compared irrespective of time as an attending *versus* time spent training. This method of categorization was chosen to account for an average 64-wk publication lag (submission to publication time) in 2019 for articles submitted to *Plastic and Reconstructive Surgery*, prior to the COVID-19 pandemic.[13]

An example of this categorization process is shown in Figure 1. A candidate graduating medical school in 2007 and pursuing a 6-y integrated residency would have publications from 2008 and before categorized as "preresidency", 2009-2014 as "intraresidency", and 2015-2020 as "junior attending". If this candidate pursued a fellowship, their pre and intra-residency categorizations would not change, but publications from 2015 would be further categorized as fellow-year publications and 2016-2021 would be considered "junior attending" publications.[13]

Statistical analysis

All statistical analyses were carried out using STATA (13MP) with a significance level of $P < 0.05$.[14]

Descriptive analysis of publications by the year of graduation from medical school, fellowship/type of fellowship pursued, and research years in residency was compiled and reported as medians with interquartile ranges.

Linear regression evaluated relationships between pre-residency, intra-residency, and junior attending publications. A Mann Whitney *U*-test was used to determine if the decision to pursue a fellowship significantly correlated with increased total publications and publications as a junior attending. This test was chosen due to unequal variance of both variables, as revealed by the Shapiro–Wilk Test. Kruskal–Wallis H testing identified if significant differences existed between publication counts across all fellowship types. A Mann Whitney *U*-test was used to elucidate significant differences in total publications between graduates of aesthetic fellowships and all other fellowships in aggregate.

Linear regression analysis was used to determine if length of residency and graduation year correlated with total publication count. Additionally, logistic regression was performed to determine whether there was a correlation with graduation year and decision to pursue a fellowship, and whether

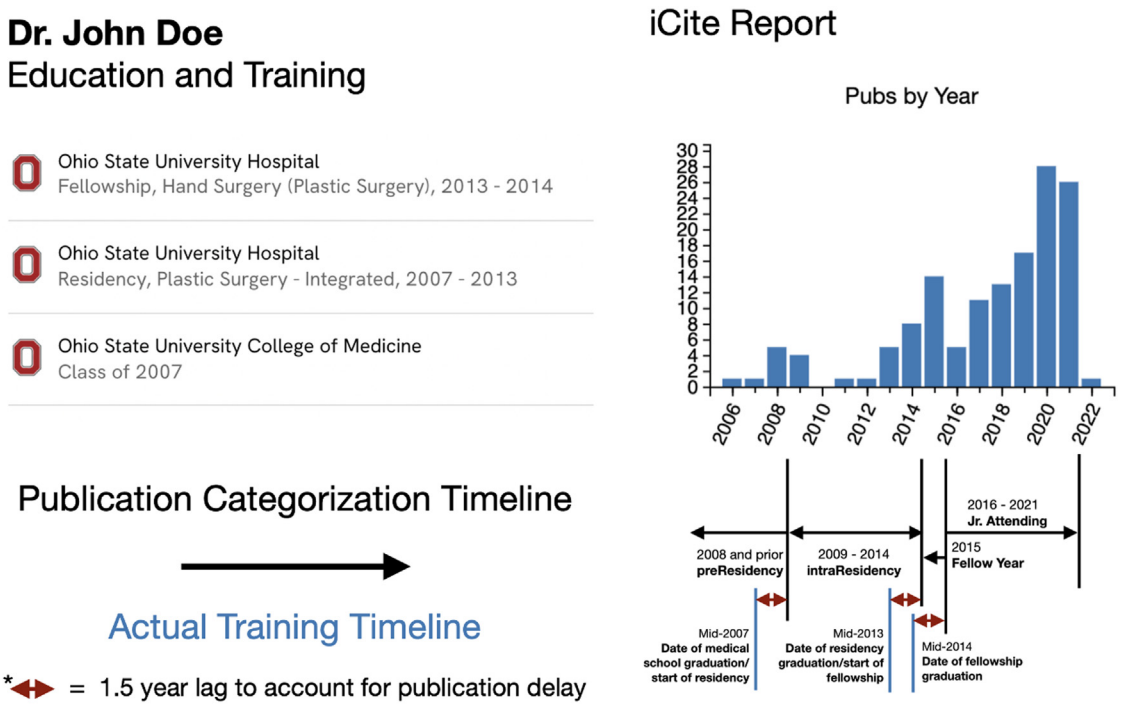

Fig. 1 – Publication categorization methodology. *Color print requested if possible.

decision to pursue a fellowship correlated with the number of intra-residency publications.

Results

A total of 1838 new American Board of Plastic Surgery diplomates were reviewed across 10 y of newsletters. Six hundred fifty-five (35.6%) integrated program graduates were included in the study. These surgeons produced a median of 4 (interquartile range [IQR], 1 to 10) total publications. The median number of publications preresidency, intraresidency, and as a junior attending were 0 (IQR, 0 to 1), 2 (IQR, 0 to 4), and 1 (IQR, 0 to 4), respectively. Given the positive skew of the data, means were not used for statistical analysis, but were found to be 0.59 ±r1.6, 3.1 ±.4.2, 5.0 ±.10.1, and 8.7 ±012.6 for preresidency, intraresidency, junior attending, and total publications, respectively.

Linear regression showed significant, albeit weak correlations of publications between preresidency/intraresidency and intraresidency/junior attending time points ($r = 0.10$, $P < 0.001$ and $r = 0.15$, $P < 0.001$, respectively). There was negligible correlation found between preresidency and junior attending publication productivity ($r = 0.019$, $P = 0.002$) (Table 1).[15]

Median total publication counts for those who pursued a fellowship was significantly higher than those who did not at 7 (IQR, 3 to 18) and 3 (IQR, 1 to 7), respectively ($P < 0.001$) (Table 2). Median junior attending publication count for those who pursued a fellowship was also significantly higher than those who did not at 2 (IQR, 0 to 10) and 1 (IQR, 0 to 3), respectively ($P < 0.001$).

Kruskal–Wallis H testing revealed significant differences in total publication count between different fellowships ($P < 0.001$). The specific fellowships included hand, microsurgery, craniofacial/pediatrics, aesthetic, or a combination of multiple fellowships. Graduates of aesthetic surgery fellowships specifically had significantly fewer total publications compared to all other fellows with 4 (IQR, 2 to 7) *versus* 7 (IQR, 3 to 20) ($P = 0.004$) median publications for graduates of aesthetic and all other fellowships, respectively (Fig. 2).

A linear regression conducted on those graduating medical school between 1998 and 2006 showed a significant relationship between the year of graduation and total publication productivity with a correlation coefficient of 0.89 ($P < 0.001$). Only surgeons graduating between 1998 and 2006 were included in this regression to avoid outliers from graduation years with low sample size that could sway data. Median publication counts in this period ranged from 2 (IQR, 1 to 6) in 1998 to 9 (IQR, 4 to 15) in 2006 (Table 3 and Fig. 3). Over the

Table 1 – Linear regression coefficients between preresidency, intraresidency, and junior attending publications.

Time period	Pre-residency publications	Intra-residency publications
Intra-residency publications	0.10 ($P < 0.001$)*	
Junior attending publications	0.0193 ($P = 0.002$)*	0.15 ($P < 0.001$)*

* Significant ($P < 0.05$) correlation.

Table 2 – Publications by fellowship.

Fellowship pursued	Median number of publications (IQR, *n*)
None	3 (1 to 7, 444)
Any fellowship	7 (3 to 18, 211)
Median publications by specific fellowships (IQR, *n*):	
Hand	5 (3 to 13, 97)
Microsurgery	10 (3.5 to 25.5, 36)
Craniofacial & pediatrics	14 (8 to 29, 26)
Aesthetic	4 (2 to 7, 25)
Multiple	12 (4 to 29, 27)

same time, a significant relationship was found between the year of graduation and decision to complete fellowship ($P < 0.001$, odds ratio = 1.20). Percent of graduates completing fellowship ranged from 17.65% to 40.68% from 1998 to 2006, respectively (Fig. 4). A significant relationship ($P < 0.001$, odds ratio = 1.46) was also found between the decision to complete fellowship and number of intraresidency publications with median intra-residency publication counts being 2 (IQR, 1 to 6) and 1 (IQR, 0 to 3) for those who completed, and did not complete fellowships, respectively.

A significant linear relationship was seen between the length of residency and total publication productivity with a correlation coefficient of 4.6 ($P < 0.001$). This shows median total research productivity significantly increases as surgeons pursue research -years/extra -years in residency. Median total publication counts ranged from 3 (IQR, 1 to 6) to 8 (IQR, 7 to 18) for those who pursued a 5- and 8-y residency, respectively. A significant linear relationship was also seen between the length of residency and junior attending publication productivity with a correlation coefficient of 2.7 ($P < 0.001$). This shows that increases in research productivity associated with research years/extra years in residency go beyond a surgeon's time in residency. Median junior attending publication counts ranged from 1 (IQR, 0 to 2) to 7 (IQR, 1 to 10) for those who pursued a 5- and 8-y residency, respectively (Table 4).

Table 3 – Publications by graduation year.

Graduation year	Median number of publications (IQR, *n*)
1986	16 (16 to 16, 1)
1991	0 (0 to 3, 3)
1992	0 (0 to 0, 1)
1993	2 (1 to 20, 3)
1994	3 (3 to 28, 3)
1995	5 (3 to 5, 5)
1996	3 (1 to 7, 13)
1997	3 (0 to 8, 34)
1998	2 (1 to 6, 51)
1999	2 (1 to 6, 57)
2000	3 (1 to 6, 66)
2001	2 (1 to 9, 65)
2002	5 (2 to 12, 67)
2003	5 (2 to 10, 68)
2004	5 (2 to 15, 73)
2005	5.5 (3 to 11, 64)
2006	9 (4 to 15, 59)
2007	4 (2 to 14, 20)
2008	2 (2 to 2, 1)
2009	9 (9 to 9, 1)

Discussion

This study is the first to examine the association of research productivity between medical students, residents, and junior attendings following completion of integrated plastic surgery training. This is of importance because research before residency has increasingly become a key metric for selecting students for integrated plastic surgery residencies[1-3,13,16-20], with one survey finding 45.3% of plastic surgery program directors agree dedicated research time will become more important as the USMLE Step 1 exam transitions to pass-fail scoring.[21] Another survey went on to show that research publications were higher for matched reapplicants to plastic

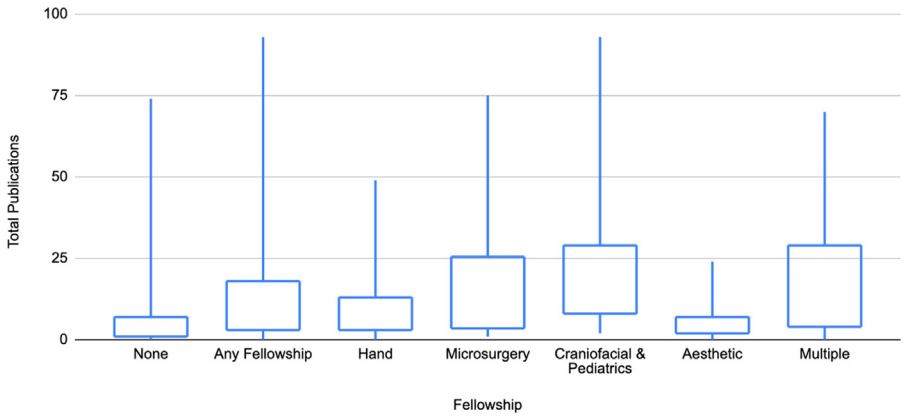

Fig. 2 – Total publications by fellowship.

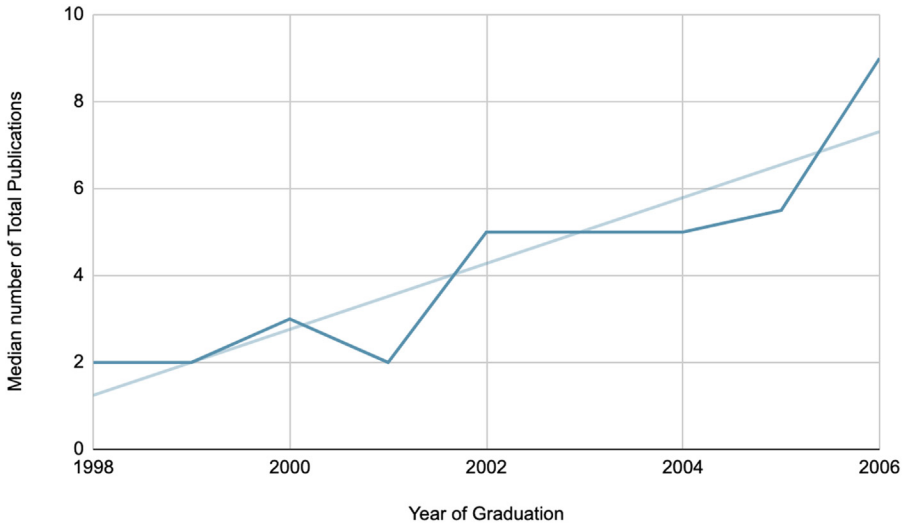

Fig. 3 – Median publications by graduation year with trendline.

surgery when compared to unmatched reapplicants.[22] However, our research reveals preresidency research does not necessarily translate into productivity at the resident and junior attending level with negligible relationship found between preresidency and junior attending publications. This suggests using medical school research productivity to select for integrated plastic surgery applicants may not be the best way to promote long term research in the field.

Recent analyses of other surgical subspecialties, namely ophthalmology[23] and orthopedic surgery,[24] found having publications in medical school was associated with increased research productivity in residency. Further, a study regarding Canadian otolaryngology residents corroborated this point by showing that publishing a paper before residency led to a 6 times greater chance of publishing during residency.[25] However, this relationship may be specialty-dependent, as a study of radiology residents found academic productivity before residency did not correlate with resident publication potential.[26] Additionally, none of these studies evaluated publications as a junior attending.[23-26]

A metric that more strongly associates with future productivity may be completing dedicated research years within residency. Our data showed integrated applicants who pursued longer residencies with dedicated research year(s) had significantly more total publications than those who complete residency in a 5- or 6-y period. Further, this significant relationship was preserved when looking only at junior attending publications. These data suggest increased publication count is a sustainable trend with these surgeons, not just a result of having dedicated time in residency to publish. This is echoed by a 2015 study, which showed plastic surgeons who pursued research fellowships, have a higher average h-index and productivity compared to other colleagues.[27] A recent 2021 study found that research years in medical school itself are linked to increased productivity as an integrated plastic surgery resident.[28] This beneficial effect of research

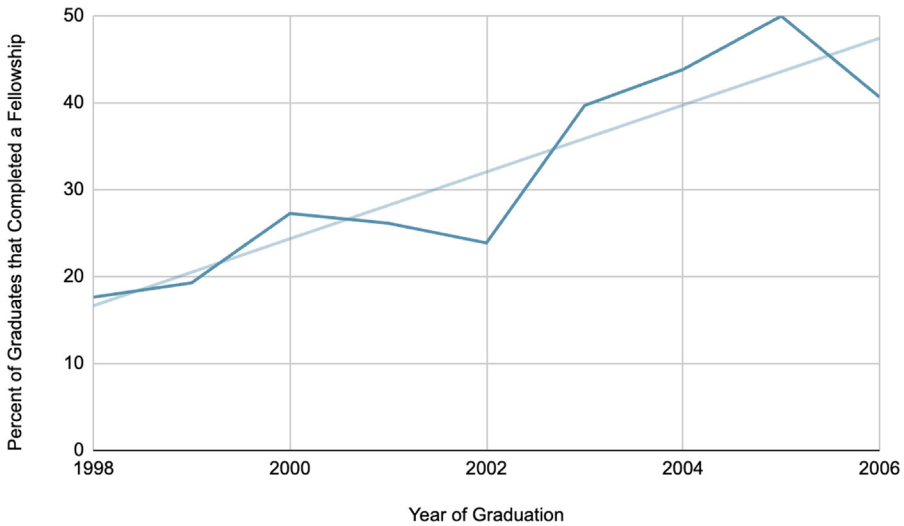

Fig. 4 – Proportion of graduates completing fellowship by graduation year.

Table 4 – Publications by length of residency.

Length of residency	N	Median number of total publications (IQR)	Median number of publications as junior attending (IQR)
5	147	3 (1 to 6)	1 (0 to 2)
6	458	4 (2 to 11)	1 (0 to 4)
7 (1 research y)	41	9 (5 to 24)	3 (1 to 16)
8 (2 research y)	9	8 (7 to 18)	7 (1 to 10)

years on overall productivity may be attributed to dedicated time to pursue research with a period of fewer clinical responsibilities.

Another metric which may be associated with research productivity is the decision to pursue a fellowship.[29] Our study found graduates of fellowships have significantly more publications as a junior attending when compared to plastic surgeons that go straight into practice. However, there is a caveat, in that those who pursue aesthetic surgery fellowships tend to have significantly fewer publications at 4 (IQR, 2 to 7) compared to 7 (IQR, 3 to 20) for all other fellows. This productivity is, however, higher than plastic surgeons who pursued no fellowships at 3 median (IQR, 1 to 7) publications.

An expected outcome of our research was finding a significant relationship between research productivity and year of graduation from medical school, with median publication count increasing with more recent graduates. As supported by our findings, the increases may be attributed to the increased rate at which surgeons have pursued fellowships overtime. Fellowships inherently add more time to academic training which often includes research requirements. Further, more publications may be required in residency to bolster applications to these fellowships, as shown by our finding that surgeons who completed fellowships had double the median intraresidency publications compared to those who did not. Another explanation for the increased publication count over time is the rising research productivity in integrated applicants necessary to remain competitive, with applicant publications increasing 100% between 2012 and 2017.[2] However, this is not to say integrated plastic surgery residency only recently became competitive. One marker of residency competitiveness is the number of ranks a matched applicant needs to submit on average to be successful. Matched residents of integrated plastic surgery residencies in 2000, on average, submitted 11.9 ranks or position.[30] This was higher than all but two specialties that year and above the average of 7.9 ranks or position.[30] This suggests integrated plastic surgery residency has been hypercompetitive in the past and remains as such today.[1] The observed trend of increased research productivity in recent years therefore points to larger trends in research productivity, not necessarily the competitiveness of plastic surgery residencies. To further this point, a similar recent increase in applicant productivity has been seen in other historically competitive residencies, including otolaryngology and dermatology.[31,32] These increases may be related to advances in technology, including improved ability to participate in remote research and expanded access to research mentors.[10]

Limitations

Excluding plastic surgeons with gap years/research years between medical school graduation and residency introduces selection bias, potentially excludes the most productive clinicians in the field.[28] Another limitation is the potentially inaccurate categorization of publications into preresidency, intraresidency, and junior attending groups. The use of the American Board of Plastic Surgery's Annual Newsletter to Diplomates to identify plastic surgeons is another limitation, as only board-certified physicians were included in the study. Further, our methodology did not consider academic appointments of surgeons, which is noteworthy as some academic positions come with mandatory publication requirements, ultimately affecting research productivity.

Conclusions

With integrated plastic surgery applicants across the board producing more research before residency, it is important to understand that preresidency productivity is not necessarily associated with resident or junior attending productivity. Programs looking to maximize research output in their graduates should consider applicants' desires to take dedicated research year(s) in residency or pursue a nonaesthetic fellowship.

Author Contributions

Mr Jinka completed the project planning, literature review, data-retrieval, analysis, and writing and revision of the manuscript. Dr Sarac came up with the project idea and completed the project planning, literature review, review of the data-analysis, and writing and revision of the manuscript. Drs Seaman and Huayllani and Ms Fry completed the data-retrieval and writing of the manuscript. Dr Janis came up with the project idea and completed the project planning, literature review, review of the data-analysis, and writing and revision of the manuscript.

Disclosure

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. Dr Janis receives royalties from Springer Publishing and Thieme Publishers. Mr Jinka, Dr Sarac, Mr Seaman, Ms Fry,

and Dr Huayllani have no financial disclosures. None of the authors have received funding.

Funding

None.

REFERENCES

1. Asserson DB, Sarac BA, Janis JE. A 5-year analysis of the integrated plastic surgery residency match: the most competitive specialty? *J Surg Res*. 2022;277:303–309.
2. Ngaage LM, Elegbede A, McGlone KL, et al. Integrated plastic surgery match: trends in research productivity of successful candidates. *Plast Reconstr Surg*. 2020;146:193–201.
3. Schultz KP, Shih L, Davis MJ, et al. Integrated plastic surgery applicant review: important factors and selection criteria. *Plast Reconstr Surg Glob Open*. 2020;8:e2892.
4. NRMP. Charting outcomes in the Match 2020 MD senior. 2020. Available at: https://www.nrmp.org/wp-content/uploads/2020/07/Charting-Outcomes-in-the-Match-2020_MD-Senior_final.pdf. Accessed November 2, 2021.
5. Ballard TNS, Sando IC, Kasten SJ, Cederna PS. Successfully integrating research into plastic surgery training programs. *J Craniofac Surg*. 2015;26:2279–2282.
6. Atesok KI, Hurwitz SR, Egol KA, et al. Perspective: integrating research into surgical residency education: lessons learned from orthopaedic surgery. *Acad Med*. 2012;87:592–597.
7. Barker JC, Rendon J, Janis JE. Medical student mentorship in plastic surgery: the mentee's perspective. *Plast Reconstr Surg*. 2016;137:1934–1942.
8. Janis JE, Barker JC. Medical student mentorship in plastic surgery: the mentor's perspective. *Plast Reconstr Surg*. 2016;138:925e–935e.
9. Odom EB, Janis JE, Gosain A, Barker JC, Buck DW. Education for the future: what the residents want. *Plast Reconstr Surg*. 2017;140:646e–647e.
10. Raborn LN, Janis JE. Overcoming the impact of COVID-19 on surgical mentorship: a scoping review of long-distance mentorship in surgery. *J Surg Educ*. 2021;78:1948–1964.
11. ABPlasticsurgery.org. Available at: https://www.abplasticsurgery.org/diplomates/newsletter-to-diplomates/. Accessed February 6, 2022.
12. iCite | new analysis | NIH Office of Portfolio analysis. Available at: https://icite.od.nih.gov/analysis. Accessed January 30, 2022.
13. Jinka SKA, Janis JE. Publication times and integrated plastic surgery applicant planning. *Plast Reconstr Surg Glob Open*. 2021;9:e4057.
14. Stata Statistical Software. Available at: https://www.stata.com/products/. Accessed January 30, 2022.
15. Schober P, Boer C, Schwarte LA. Correlation coefficients: appropriate use and interpretation. *Anesth Analg*. 2018;126:1763–1768.
16. Mehta K, Sinno S, Thanik V, Weichman K, Janis JE, Patel A. Matching into integrated plastic surgery: the value of research fellowships. *Plast Reconstr Surg*. 2019;143:640–645.
17. Janis JE, Hatef DA. Resident selection protocols in plastic surgery: a national survey of plastic surgery program directors. *Plast Reconstr Surg*. 2008;122:1929–1939.
18. Nguyen AT, Janis JE. Resident selection protocols in plastic surgery: a national survey of plastic surgery independent program directors. *Plast Reconstr Surg*. 2012;130:459–469.
19. Keane CA, Akhter MF, Sarac BA, Janis JE. Characteristics of successful integrated plastic surgery applicants from US allopathic medical schools without a home integrated program. *J Surg Educ*. 2022;79:551–557.
20. Raborn LN, Janis JE. Current views on the new United States medical licensing examination Step 1 Pass/fail format: a review of the literature. *J Surg Res*. 2022;274:31–45.
21. Lin LO, Makhoul AT, Hackenberger PN, et al. Implications of pass/fail Step 1 scoring: plastic surgery program director and applicant perspective. *Plast Reconstr Surg Glob Open*. 2020;8:e3266.
22. Patel AA, Wong MS, Nguyen VT, Janis JE. Analysis of reapplications to integrated and independent plastic surgery residency. *Plast Reconstr Surg Glob Open*. 2021;9:e3508.
23. Lin JC, Lokhande A, Scott IU, Greenberg PB. Predictors of future research productivity among ophthalmology residents. *Semin Ophthalmol*. 2021;37:345–350.
24. Kreitz T, Verma S, Adan A, Verma K. Factors predictive of orthopaedic in-training examination performance and research productivity among orthopaedic residents. *J Am Acad Orthop Surg*. 2019;27:e286.
25. Kohlert S, Zuccaro L, McLean L, Macdonald K. Does medical school research productivity predict a resident's research productivity during residency? *J Otolaryngol Head Neck Surg*. 2017;46:34.
26. Patterson SK, Fitzgerald JT, Boyse TD, Cohan RH. Is past academic productivity predictive of radiology resident academic productivity? *Acad Radiol*. 2002;9:211–216.
27. Sood A, Therattil PJ, Chung S, Lee ES. Impact of subspecialty fellowship training on research productivity among academic plastic surgery faculty in the United States. *Eplasty*. 2015;15:e50.
28. Applebaum SA, Stoehr JR, Bacos JT, et al. Do dedicated research years during medical school predict academic productivity during residency? *Plast Reconstr Surg Glob Open*. 2021;9:e3849.
29. Chopra K, Swanson EW, Susarla S, Chang S, Stevens WG, Singh DP. A comparison of research productivity across plastic surgery fellowship directors. *Aesthetic Surg J*. 2016;36:732–736.
30. Archives. NRMP. Available at: https://www.nrmp.org/match-data-analytics/archives/. Accessed April 22, 2022.
31. Ezekor M, Pona A, Cline A, Huang WW, Feldman SR. An increasing trend in the number of publications and research projects among dermatology residency applicants. *J Am Acad Dermatol*. 2020;83:214–216.
32. Bowe SN, Schmalbach CE, Laury AM. The state of the otolaryngology match: a review of applicant trends, "impossible" qualifications, and implications. *Otolaryngol Head Neck Surg*. 2017;156:985–990.