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Pushing the needle of entrepreneurship and innovation: Where do plastic and reconstructive surgeons stand?

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Pushing the Needle of Entrepreneurship and Innovation: Where Do Plastic and Reconstructive Surgeons Stand?

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Background: Plastic and reconstructive surgery has a well-recognized history of disruption and innovation. It remains unclear, however, how the specialty's priority on innovation materializes into commercialization or bench to bedside led by plastic surgeons.

Methods: Our analysis utilized Pitchbook (Seattle, Wash.), a market database of companies and investors, for ventures that have designed innovations related to plastic and reconstructive surgery. Companies were categorized into 5 focus areas: provider (outpatient surgical or hospital entity), aesthetics (cosmetics/injectables), devices (instrumentation, lasers, implants), regenerative medicine (tissue engineering/wound healing), and software (digital solutions). Company websites, LinkedIn (Sunnyvale, Calif.) profiles, and Crunchbase (San Francisco, Calif.) were reviewed to determine the leadership roles of plastic surgeons.

Results: Plastic surgeons primarily serve as advisors, as opposed to founders or chief executive officers (CEOs). Our analysis additionally found that provider and software solutions had a greater degree of plastic surgeon-led leadership, whereas regenerative medicine and device innovation remains less frequented. There was a relatively balanced representation of academic and private plastic surgeons in entrepreneurial pursuits.

Conclusions: Plastic surgeons typically serve as board advisors, as opposed to founders and CEOs. Reasons for disengagement from leadership roles may include satisfaction with clinical work, time constraint, lack of business knowledge, financial constraint, and opportunity cost associated with starting a venture. To promote participation in innovation, future studies should explore tangible ways to engage in such opportunities. In doing so, plastic surgeons can own the "organ" of innovation, and continue to contribute to the legacy and the advancement of the specialty.
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INTRODUCTION

Plastic and reconstructive surgery has a well-recognized history of disruption and innovation.[1–6] Our specialty has been defined by those who push the needle, such as Harry Buncke, an innovator in microsurgery, Joseph Murray, the Nobel Prize-winning pioneer of kidney transplantation, and Paul Tessier, a visionary for modern craniofacial surgery.[7–9] These narratives have permeated to successive generations of plastic surgeons, and echo the foundational principles of creativity and vision within our specialty. Plastic surgeons do not "own" a single organ in the body, and as a result, have relied on their ability to innovate to confer a sense of identity within our broader surgical community.[7] We have followed suit of our visionaries and have ventured into new frontiers of our field—such as gender-affirming surgery, targeted muscle reinnervation, facial transplantation, and the like—to contribute to the spirit of innovation. This entails the translation of a new idea, process, or product designed to save energy and improve patient care. The inherent problem-solving nature of plastic surgery promotes a mindset of curiosity and inquiry.

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Plastic surgeons may source inspiration from the clinic, operating room, research laboratory, from patients, colleagues, or the world outside the hospital. These discoveries often take shape in the form of research publications and conference presentations for the academic community. However, others may channel this spirit of innovation of their basic and clinical research through translation through commercialization.

With the tremendous growth of the aesthetic surgery, tissue engineering, and regenerative medicine industries, plastic surgeons have unparalleled scientific and surgical expertise with the potential to revolutionize our field.[10,11] While some may file patents and pursue incorporation as an organizational entity, others may choose to participate through key opinion leader (KOL) or advisory board member roles. Regardless, it remains unclear how plastic surgery's priority of innovation materializes into opportunities for commercialization and how plastic surgeons participate in such endeavors.

We hypothesize that plastic surgeons are well-represented in leadership roles within regenerative medicine and device solutions, as their operative and clinical expertise offer valuable contributions within these sectors. We additionally posit that there will be a greater proportion of academic practice plastic surgeons, relative to their private practice counterparts who engage in entrepreneurial pursuits, given their access to university-based resources such as research laboratories, affiliated incubators, and adjunct business schools. This investigation sought to understand the role of plastic surgeons in ventures that pertain to the specialty of plastic surgery.

METHODS

A retrospective review of United States-based plastic surgery companies was performed using Pitchbook (Seattle, Wash.), a public market database composed of companies and investors. Data were analyzed from investments posted in January 1, 2011 through December 31, 2019.[12] Each company's focus area was determined based through Google search (Google LLC, Mountainview, Calif.). Five focus areas were identified: provider (outpatient surgical or hospital entity), aesthetics (cosmetics/injectables), devices (instrumentation, lasers, prosthetics, implants), regenerative medicine (tissue engineering or wound healing solutions), and software (digital solutions for patients or surgeons). In addition, company websites, LinkedIn (Sunnyvale, Calif.) profiles, Crunchbase (San Francisco, Calif.), and Pitchbook were reviewed to determine the educational background and expertise of the executive leadership team.[12–14] Company websites that were not in English were omitted for this analysis. The specific roles (ie, founder(s), chief executive officer (CEO), chief medical officer (CMO), advisors, etc.) held by plastic surgeons and other medical providers were recorded for each company.

RESULTS

A total of 64 companies were included in the analysis. Nearly a fifth (19%) of companies had plastic surgeons as founders, and 9 (14%) had them as CEOs. Plastic surgeons more commonly served as board advisory members, as they were represented in 23% of companies. Of the 40 plastic surgeons involved in various leadership positions, there were 9 (23%) CEOs, 12 (30%) founders, 15 (37.5%) advisors, and 4 (10%) CMOs (Fig. 1). There was a relatively even divide between the representation from academic (36%) and private practice (39%) surgeons. Of the 93 founders represented, 39 (42%) had MD or MD/PhD degrees, followed by 22 (24%) having exclusively PhD degrees, 16 (17%) with master's (ie, MBA, MSE, MSc, etc), 13 (14%) with bachelor's, 2 (2%) with JD, and 1 (1%) with a high school diploma as the highest educational degree completed (Fig. 2A). Approximately one-fifth of physicians were not plastic surgeons, and instead hailed from dermatology, orthopedic surgery, and general medicine. Of the 63 CEOs analyzed, 16 (25%) had MD, MD/PhD, or MD/MBA degrees, 16 (25%) had PhDs, 17 (27%) had some type of master's degree, and 14 (22%) had a bachelor's in this executive role (Fig. 2B).

In terms of focus area, there were 9 aesthetic companies, 13 device, 15 provider, 5 software, and 22 regenerative medicine solutions, amounting to a total of 64 ventures analyzed. Plastic surgeons comprised a relatively larger proportion of founders in software (60%) and provider (33%) solutions, as opposed to regenerative medicine (11%) and device (15%) solutions (Fig. 3A). In contrast, plastic surgeons had a balanced representation across focus areas, with the exception of regenerative medicine and device solutions in CEO roles (Fig. 3B).

DISCUSSION

Our results reveal the under-representation of plastic surgeons in the leadership structures of start-up ventures related to their idea or specialty. This finding has many potential origins. All are related potentially to the opportunity cost of choosing to run a start-up and of incurring significant risk associated with foregoing reimbursement associated with one's own academic or private practice and activities that might provide a greater chance of institutional advancement or promotion. Time constraint is an additional consideration, as plastic surgeons must balance responsibilities as full-time clinicians, principal investigators, and educators. Financial constraints could also serve as a barrier to starting a company, as student debt and personal obligations may preclude some from entrepreneurial endeavors. Moreover, instead of starting a company, plastic surgeons may elect to maintain relationships with industry companies through serving as consultants, organizing clinical studies, and receiving royalties for the use of various devices, biologics, and software.[15–18] On the other hand, plastic surgeons may choose not to participate in the process of commercialization due to potential conflicts of interest and concerns of how they are viewed by the public, patients, and fellow colleagues.[19–23] Finally, entrepreneurship in the form of start-ups may be perceived as high risk and may require a certain level of industry contacts and relationships with investors that most plastic surgeons do not seek.

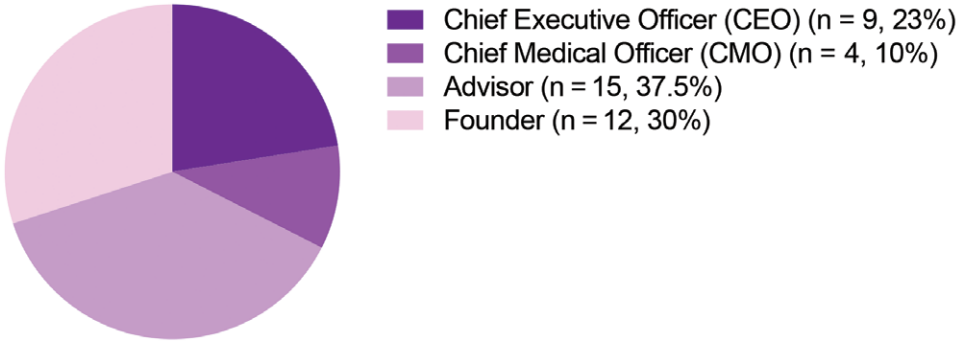

Fig. 1. Roles of plastic surgeons in plastic surgery companies.

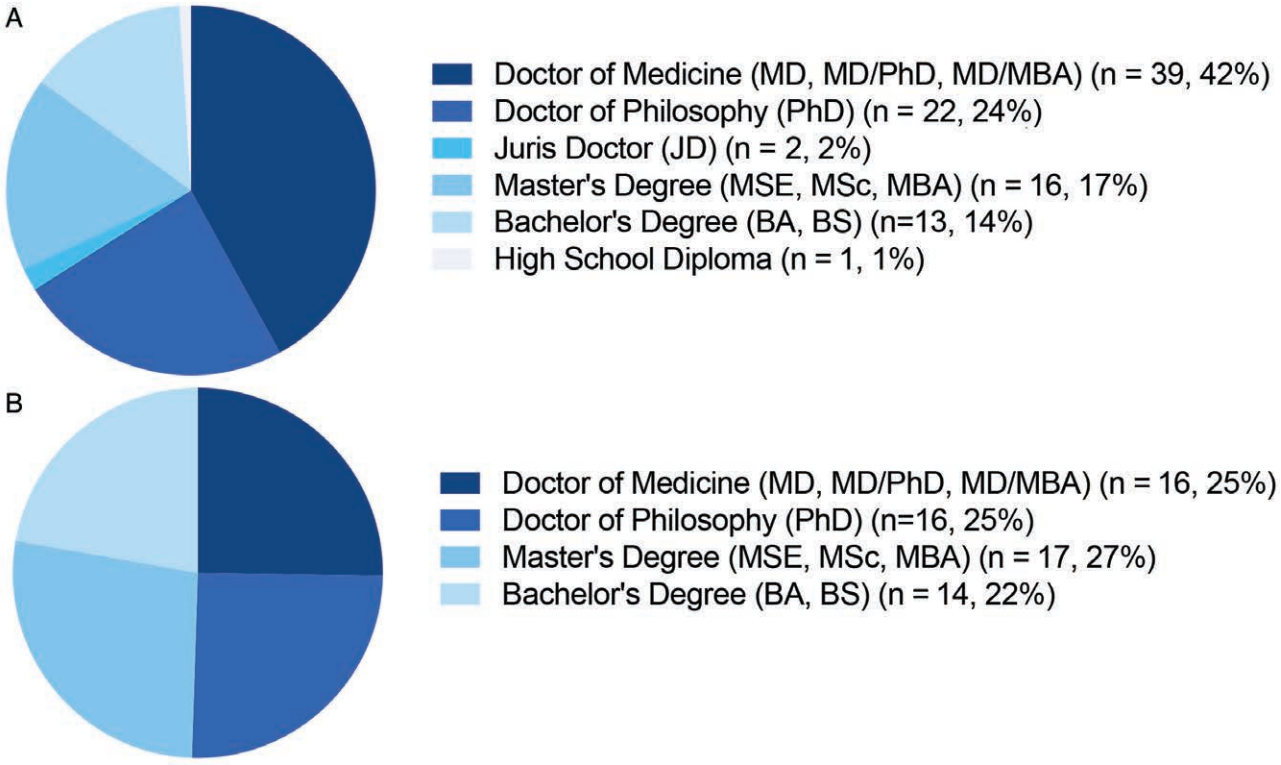

Fig. 2. A, Educational levels of founders for plastic surgery–related companies. B, Educational levels of CEOs for plastic surgery–related companies.

If involved, we found plastic surgeons commonly occupy roles on the advisory board. Such positions can allow plastic surgeons to contribute their experiences within academia, draw inspiration from their work, and remain at the forefront of innovation amidst these constraints.[24–26] This method of participation within commercialization and healthcare ventures has been increasingly common among physicians in all specialties, in addition to plastic surgery.[24–26]

According to our findings, plastic surgeons are more likely to be founders or CEOs of companies that offer provider solutions, such as private practices and ambulatory surgical centers (ASCs). Plastic surgeons may prefer to pursue entrepreneurial opportunities that are closely interlinked with daily surgical practice, as their reputational and financial success are dependent on favorable surgical patient outcomes and clinical productivity. The predominance of plastic surgeons as leaders in provider solutions could also be attributed to the fact that the majority of residency graduates pursue careers in private practice. In fact, some studies have estimated that 67%–90% of plastic surgeons choose this path, and thus often serve in executive leadership positions (ie founder, CEO) in such practices.[27,28] Additionally, one could consider the burgeoning role of ASCs, which have been regarded as optimal sites for surgical intervention, cost reduction, patient satisfaction, privacy, productivity, and convenience to both plastic surgeons and patients.[29] The Center for Medicare and Medicare Services has also incentivized the use of ASCs, providing greater reimbursement to surgeons who are operative in these settings, as opposed to hospital outpatient departments.[30] In all, provider solutions are

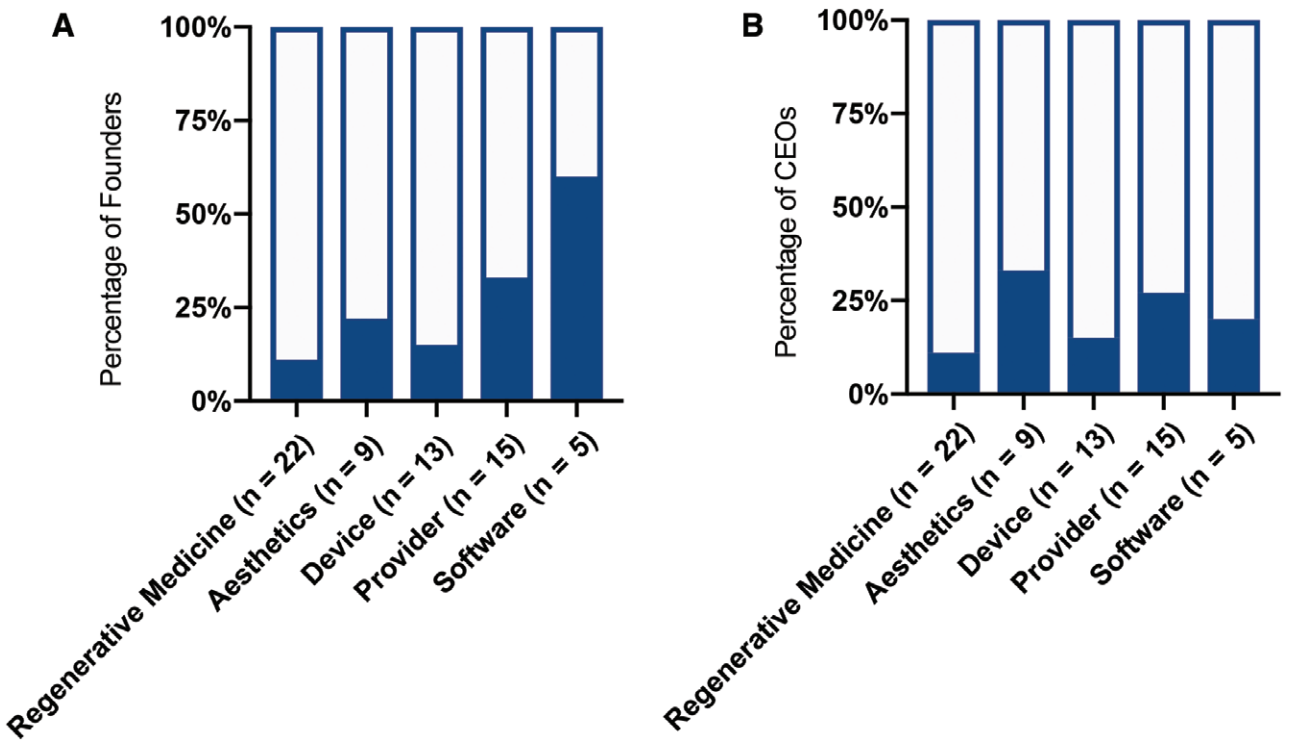

Fig. 3. A, Percentage breakdown of plastic surgeons as founders by company focus. B, Percentage breakdown of plastic surgeons as CEOs by company focus.

an accessible method by which plastic surgeons excel as leaders, and concurrently provide a high quality of care to their patients.

Software solutions, which comprise remote monitoring, virtual surgical planning, and telemedicine, were most commonly (60%) led by plastic surgeons in executive leadership roles. This could be attributed to a promise of greater financial returns associated with digital health ventures.[31] However, these companies represented only 8% of those analyzed in our study, and may suggest a lag of digital health applications in plastic surgery. Interestingly, however, investment value in software and digital health has increased by 858% and the number of investments by 412%, in the past decade.[31] Institutional efforts have been taken to increase investment in digital health, specifically the Food and Drug Administration (FDA)'s establishment of the Digital Health Center of Excellence. This entity aims to empower stakeholders to advance healthcare through response and high-quality innovation.[32] Within the field of plastic surgery, there are great opportunities for digital health ventures. Virtual surgical planning and simulation technologies are attractive from the standpoint of offering precision care for optimal aesthetic results for patients. Telemedicine, defined as the use of information technology and telecommunication to provide healthcare, has great potential for use within plastic surgery—whether through triaging trauma patients, monitoring postoperative wounds, or performing consultations for elective procedures.[33] With the resurgence of the Coronavirus pandemic, digital heath solutions within all specialties, including plastic surgery, will continue to rise in the coming months.[34] Given the promise of digital health innovation, we urge plastic surgeons to leverage their surgical expertise and consider the applications of software solutions for the sake of improving clinical outcomes and aesthetic results for patients.

Regenerative medicine solutions, composed of tissue engineering and wound healing companies, had a low representation (11%) of plastic surgeons as founders and CEOs. Instead, engineers and research scientists, with PhDs, comprised the vast majority of leaders in such companies. Furthermore, the FDA and national government has increasingly prioritized innovation within regenerative medicine, allocating greater research and development funds through the 21st Century Cures Act.[35] From a financial perspective, the tissue engineering market is quite robust, as the market amounted to $9.0 billion in 2019, and is expected to rise at a compound annual growth rate of 14.2% from 2020 to 2027.[4] Although plastic surgeons have variable interests in the applications of basic science to their specialty, it is important to consider how academic plastic surgeons interact regularly within the fields of tissue engineering, 3-dimensional printing, and biologics in the laboratory and thus, have great potential in translating their research discoveries to venture opportunities. Surgeons have unparalleled insight into the issues affecting their patients, and can serve as a foundation of new ideas and insights, as well as revision of older constructs.

Device companies, which manufacture lasers, surgical instruments, implants, and prosthetics, also had a low representation (15%) of plastic surgeons in executive leadership roles. Through advisory roles, plastic surgeons

may contribute their perspective as chief users of various devices; they may provide feedback regarding product features, settings, and utilization to company representatives. They carry comprehensive knowledge of a given device's capabilities and limitations in a particular patient or medical condition. This clinical and practical expertise is unparalleled, and should serve as inspiration for plastic surgeons to start ventures that design and deliver devices, and ultimately, enhance care for patients.

There was a slightly greater representation of academic plastic surgeons, compared with those in private practice, within executive leadership positions. Such engagement of academic plastic surgeons could be attributed to their increased access to surgical innovation incubators, interdisciplinary expertise, and technology transfer offices.[36,37] Some academic institutions, such as University of Michigan (Surgical Innovation and Entrepreneurship Development Program), Stanford University (BioDesign), University of Utah, University of Minnesota (Innovation Fellows Program), Mayo Clinic (Center for Innovation), and Northwestern University (NUvention), have embraced an innovation agenda, spearheading a variety of entrepreneurship development programs and internship opportunities for surgical trainees.[38–48] These programs may educate aspiring surgeon-entrepreneurs on topics such as product design, patent filing, licensing, talent recruitment, shareholder equity, and fundraising to drive clinical and research-borne innovations forward. These opportunities may integrate the expertise of adjunct business, law, engineering, and design schools to build a well-versed, diverse team. We advocate for a continued effort by academic plastic surgery sections and departments to share these offerings with trainees and faculty and ultimately, encourage the utilization of these resources.[38–48] More broadly, we recommend that national plastic surgery societies, such as the American Society of Plastic Surgeons and the Plastic Surgery Foundation, similarly encourage this agenda through offering seed grants and pitch opportunities to spur innovation amongst private and academic plastic surgeons. In addition, such societies may develop co-membership opportunities with other entities, such as business schools and other medical societies (ie, dermatology, otolaryngology) to foster synergy and commercialization.

To further explain their relative under-representation of leadership roles, plastic surgeons may abstain from engaging in entrepreneurial pursuits due to lack of business-related knowledge. Moreover, a recent study surveyed plastic surgery program directors and discovered discrepancies between perceived importance of a business education and the resources available for plastic surgery residents to learn about such concepts.[49] Another study reported that nearly 90% of plastic surgeon respondents stated that business principles are either "pretty important" or "very important" to being a doctor.[50–52] Efforts to incorporate a business curriculum for plastic surgery residents have been undertaken at several institutions, such as Johns Hopkins University, Washington University School of Medicine, and our own, Yale University.[53] These curricula have been administered through lecture series and case discussions, and have educated on topics such as billing and coding, leadership, investing, and negotiation. Despite these advances, the adoption of a standardized national curriculum within integrated plastic surgery residencies is yet to occur. We urge such institutions to leverage adjunct business, engineering, and law schools to share instruction on the process of commercialization, which may discuss the concrete steps that translate an idea to clinical reality. Future studies should assess whether such a curriculum translates to a greater probability of starting ventures within plastic surgery.

There are several limitations to this study that warrant consideration. First, our analysis does not have a record of all nonpublic funding investments, and thus does not account for all companies for which plastic surgeons may participate in. Such data are not available through Pitchbook. Second, the subjective characterization of investments may have introduced uncertainties, and thus, mislabeling of plastic surgeon engagement in various sectors. Third, while company websites, LinkedIn profiles, and Crunchbase portals were assessed for involvement by plastic surgeons, these might not have comprehensively recorded their roles. This ultimately underestimates the engagement of plastic surgeons in executive leadership positions and informal advisory roles. Future studies could survey national plastic surgery societies to attain more granular information regarding participation and interest in commercialization and entrepreneurship. Fourth, our study did not delve into the respective roles of academic and private plastic surgeons in a given commercial endeavor. Future investigations could elucidate how a particular clinical setting may be associated with innovation and formalized leadership in a given therapeutic area.

CONCLUSIONS

Despite these limitations, it is important to recognize the immense potential for plastic surgeons to engage in the process of commercialization. As a specialty known by its drive to innovate, we urge plastic surgeons to consider the application of their clinical and research-borne discoveries to impact patients beyond their scope of practice. Bench to bedside progression of ideas can be a driving force for innovation within the field of Plastic Surgery. Provider and software solutions had a greater degree of plastic surgeon-led leadership, and may reflect the tendency to interlink one's daily surgical practice with entrepreneurship. Despite their emphasis on scientific and surgical experience, regenerative medicine- and device-based ventures had less involvement by plastic surgeons in leadership positions. To promote participation within surgical innovation, future studies should explore tangible ways in which plastic surgery residents, fellows, and attendings can learn about business fundamentals, connect with a multi-disciplinary team, and leverage resources, such as patent attorneys, technology transfer offices, and grants, to be successful in their entrepreneurial pursuits. In doing so, plastic surgeons can comprehensively own the space of innovation, and contribute to the legacy of entrepreneurship so passionately instilled in all of us—for the sake of patients and the advancement of the specialty.

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