Clinical Journal of Plastic and Reconstructive Surgery
An official Journal of KGMU Plastic Surgery Education Foundation

EDITORIAL
Volume 4 | Issue 1 | January-June 2026
Published on: 9th August, 2026
www.cjprs.in

Training the Plastic Surgeon of Tomorrow: What Should Change?

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Keywords:
Plastic surgery, artificial intelligence, training program

doi: 10.61081/cjprs/4v1i101

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***Conflicts of interest:** None declared.*

***Funding:** None declared.*

***How to cite:** Kumar V, Bhat S, Kumar V. Training the Plastic Surgeon of Tomorrow: What Should Change?. Clinical Journal of Plastic and Reconstructive Surgery. 2026;4(1):1–4*

Plastic surgery as an entity has evolved dramatically over time. To remain viable, this specialty relies on innovative techniques, new anatomical understandings, and the ability to challenge conventional wisdom. Every generational period has seen the emergence of new technological advances in the field—technological advances from traditional surgical approaches to microsurgical reconstructive procedures; from craniofacial reconstructive procedures to perforator flaps and vascularized composite allotransplantations; from regenerative medicine to emerging technologies such as artificial intelligence, robotic surgery, three-dimensional printing, indocyanine green angiography, virtual planning, and precision medicine. As these newer technologies become increasingly prevalent within plastic surgery and begin to be integrated into daily practices for plastic surgeons, the question becomes not when or if plastic surgery will continue to evolve, but how quickly our current training programs can adapt to these evolving changes.

Although many elements of the Halstedian model remain a foundation for the way that surgeons are educated today — e.g., through a process of increasing responsibility as well as through an apprentice relationship with a senior surgeon — the world of residency training has changed significantly since the model's development. Residents learn by "watching," "assisting," "operating," "managing complications," and developing their own judgment. These skills cannot be acquired solely by reading a textbook. In plastic surgery specifically, because it requires unique combinations of fine motor dexterity (tissue handling), three-dimensional thinking (planning for reconstruction or repair), intraoperative decision-making, and the ability to understand aesthetics, a trainee's learning experience can never be fully replicated in an academic setting. Reduced working hours, increasing procedural complexity, operating room efficiency pressures, patient-safety expectations, and medicolegal concerns have all changed the traditional learning curve.[2]

The need of the hour is not to discard apprenticeship but to strengthen it with structure. Mere exposure to cases cannot be the only measure of training. A resident may complete the required duration of a program and still have uneven experience depending on institutional case mix, faculty interest, available technology, and the degree of autonomy permitted. The modern educational model of surgery must transition away from time spent in training toward competency demonstrated. Competency-based medical education (CBME) is designed to emphasize defined outcomes, progressive assessments, feedback, and a trainee's readiness for independent clinical decision-making rather than simply meeting the required number of months of residency.[3]

In plastic surgery, competency is best measured through practical application. The resident who completes their MCh, DNB, or equivalent plastic surgery program should feel competent in managing most common acute trauma, soft tissue loss, hand injuries, burns, vascular reconstruction, brachial plexus injury, and

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general reconstructive cases. At the completion of training, residents should be familiar with workhorse free flaps, including radial forearm free flaps, anterolateral thigh flaps, and fibula flaps. While fellowships will continue to provide invaluable refinement and sub-specialization opportunities, they should not require all residents to extend their postgraduate training solely to develop confidence in the skills and techniques that comprise the foundation of modern reconstructive plastic surgery. Research concerning readiness to perform surgeries and plastic surgeons' readiness to perform plastics has identified the significance of graduated autonomy; the nature of supervisory involvement; and the potential gap(s) in knowledge/experience that exist even after completing formalized training.[4,5]

Microsurgery will no longer be able to be viewed as simply optional or occasional exposure. Free tissue transfer has become a routine part of modern reconstruction, and the reconstructive ladder has gradually evolved into a reconstructive elevator, where the most appropriate option may not necessarily be the simplest local option. Residents should be actively involved in flap selection, perforator planning, flap harvest, microvascular anastomosis, inset, postoperative monitoring, and management of complications. Training limited primarily to local and pedicled flap reconstruction does not prepare a resident adequately for current reconstructive practices. In that, as reconstructive surgery continues to move towards thinner perforator flaps, chimeric flaps, lymphatic surgery, toe transfers, and even smaller free flaps in correcting distal digital defects, training has to be based on establishing comfort with common free flaps prior to thinking creatively and safely of new reconstructive options.[6]

Simulation, cadaveric dissection, and skill labs are, therefore, required training. Simulation will never substitute for real surgery; however, simulation may be used to prepare residents before they enter the OR. Synthetic models, animal tissues, cadaveric dissections, virtual reality, and microscope-based training will all provide deliberate practice in a safer and controllable environment.[7-9] Anatomy must be understood not just as structures but also layers, planes, perforators, pedicles, and tissue relationships. Cadaveric dissections should be performed regularly at training institutions. Fresh cadavers would be ideal, when possible, with arterial dye injected into the cadavers to demonstrate vascular anatomy, perforator location, flap territory, and safe dissection plane. This applies to both reconstructive and aesthetic surgery, as understanding facial fat compartmentalization, retaining ligamentous attachments, and layering anatomy are important.

Each training program should develop its own skill lab. The cost does not have to be high. A microscope and basic microsurgical instruments, a simple vessel model (silicone tube), chicken thigh vessel models, a box trainer, and consistent supervision sessions can help residents achieve the endurance, steadiness, and confidence needed to operate for extended times under magnification or endoscopic vision. Endoscopic procedure training modules, hair transplantations, tendon repairs, vessel anastomoses, nerve coaptations, local flap designs, perforator dissections, cleft markings, craniofacial planning, and flap-based reconstructions can make them ready for clinical application.[10] What is necessary is not luxury but consistency.

The plastic surgeon of tomorrow must also be technologically literate. Three-dimensional printing has shown great potential as a tool for preoperative planning, custom-made modeling (for example, patient-specific), reconstructive craniofacial surgery, planning for perforator flaps, educational materials for patients, and education for surgical trainees.[11] Angiography with indocyanine green has become an important intraoperative evaluation tool for assessing blood flow in free flaps and can affect decisions regarding flap harvesting, inset, or revision.[12] Virtual planning, creating patient-specific implants, using augmented reality, and digital photography are all becoming increasingly popular applications in craniofacial/head & neck/trauma/oncology/aesthetic reconstructions. Training residents does not require that they be proficient with each and every device but rather that they have a basic knowledge of the underlying principles, appropriate use, limitations, and costs. Therefore, graduates should learn the basics of these instruments prior to beginning their own practice.

Early introduction to robotic surgery is also important. The use of robotics in plastic surgery

has many directions it could go; however, it is currently being evaluated for a number of areas, including microsurgery/super-microsurgery/lymphatic surgery/peripheral nerve surgery/transoral reconstruction/breast reconstruction/minimally invasive flap harvesting. Structured curricula have been proposed for plastic surgery trainees, including theoretical knowledge, simulation, bedside assistance, console training, communication, and team coordination.[13] At this time it would not be possible for all programs to have their residents on the robotic console; therefore, as an absolute minimum, they need to be made aware of what it is, where it can be used today, its limitations, the financial barriers that exist, and the potential uses of robotics in the near future.

Artificial intelligence is another area that training programs can no longer ignore. AI is currently being used in several areas within plastic surgery (machine learning, deep learning, natural language processing, facial recognition, burn assessment, flap monitoring, craniosynostosis planning, aesthetic analysis, and decision support).[14] Many residents are now using AI-based tools to search literature, write papers, create presentations, organize data, and learn independently. Rather than viewing these advancements in technology as threats, educational programs should provide instruction on how to utilize AI responsibly. Generative AI can assist with surgical education through interactive learning materials, procedural guidance, feedback, and personalized learning; however, the use of generative AI requires the oversight/verification of a supervisor.[15,16] The resident will need to understand how to build prompts, check their findings against primary literature, and recognize hallucinated references within referenced literature. The resident needs to ensure that they maintain patient confidentiality and avoid manipulating images inappropriately. Additionally, the resident needs to disclose if the resident received assistance from AI when required by journal or institutional policy.[17] AI should be viewed as assisting human intelligence and not replacing the role of reading, reasoning, exercising surgical judgment, being creative/original, or being accountable.

The way we currently approach research training in plastic surgery must also be reevaluated. Plastic surgery has evolved through surgeons' observation of problems, questioning current practices, and documenting improved methods. However, many residents see research as another requirement to obtain promotion/examination success, rather than a normal progression of their clinical work. We need to educate our residents on how to create relevant clinical questions, collect prospective data bases, measure outcomes using validated tools/scales, disclose complications truthfully, and evaluate evidence critically. The principles of evidence-based medicine are not contrary to surgical creativity; they provide accountability so that creative innovations do not become unproven anecdotes.[18]

Departments can promote this culture of innovation by providing structured spaces for innovation. A weekly departmental meeting may be used to discuss, "What new things could we attempt, and why?" Residents can present their findings from recent literature, propose changes or modifications to existing techniques, consider feasibility, and receive guidance on safety, ethics, and practicality from faculty members. Not all ideas will be accepted; also, not every idea that is developed will make it into the operating room. However, the process of searching literature, thinking independently, defending one's reasoning, and balancing creativity with patient safety is what teaches residents how to do these tasks.

At the same time, the plastic surgeon of tomorrow must be defined by more than just technical skill, publications, and technology. Plastic surgery deals with identity, function, appearance, dignity, and quality of life. Whether treating a child born with a congenital anomaly, a worker with hand trauma, a cancer survivor requiring reconstruction, or an aesthetic patient with high expectations, communication and judgment are as important as the execution of the operation. Residents must be trained in counseling, consent, expectation management, dealing with complications, teamwork, ethics, and long-term follow-up.

Resident well-being is just as important. While it is essential that surgical training continue to be challenging (plastic surgery can't be casually learned), this does not mean that the rigors of surgical residency need to include excessive hardship. The older notion that exhausting oneself through the work environment equals a sense of commitment to one's profession needs to be re-examined.

Documentation has shown that burnout, mistreatment, discrimination, and psychological distress are all issues experienced by surgical residents. These problems do not end at the individual level. They affect both the quality of patient care and ultimately the ability of an institution to sustain its workforce.[19] The training program needs to be more than just the sole responsibility of residents in regard to building their own resiliency. The institution has a role in creating a supportive environment that promotes psychological safety, mentorship, reasonable distribution of duties, constructive feedback, and support for balancing work with life (work-life integration). Residents should have sufficient time to rest, read, pursue physical activity, maintain family and relationships, enjoy hobbies, and develop personally. Residency is not about eliminating these activities, but instead it will promote both the emotional stability of the resident and his/her ability to continue in this field over time. When a surgeon has the opportunity to grow as a person during his/her residency program, it is much easier to foster a true passion for plastic surgery as opposed to simply surviving through residency.

Therefore, it is not the spirit of plastic surgery education that needs to change but rather how we educate our next generation. Less reliance on happenstance exposure and more intentional competence. Less passive observing that more autonomously supervised training; less reluctance to use technology, more responsible adoption of technology, and less glorifying burnout, more mentoring sustainably. The plastic surgeon of the future will not just be defined by new flaps, machines, or algorithms. He/she will be defined by the type of surgeon we train. Tomorrow's plastic surgeons will have to be technically proficient, capable microsurgeons in their work with scientific curiosity, digital literacy, ethical foundations, emotional maturity, and adaptability. The best training programme is not one that merely produces a surgeon who can pass an examination. It is one that produces a surgeon who can think clearly in uncertainty, operate safely under pressure, learn continuously, innovate responsibly, communicate honestly, and care deeply. The most important innovation in plastic surgery will not be a robot, an algorithm, or a new flap. It will be the 'surgeon', Mentors prepare to use them.

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