

EDITORIAL

Why robotic microsurgery?

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Introduction

Surgical progress has rarely occurred in isolation from technological advancement. Across disciplines, innovations such as laparoscopic surgery and robotic platforms have repeatedly challenged established norms, often meeting understandable scepticism before becoming embedded in routine practice. Plastic and reconstructive surgery is no exception.

Prior to the 1970s, many conditions now routinely managed with microsurgical reconstruction were either untreatable or required prolonged, staged and morbid procedures. The seemingly simple but transformative concepts of improved visualisation (through the operating microscope) and the availability of reliable microsurgical instruments, combined with structured training and advancing anatomical knowledge, allowed surgeons to operate consistently at a previously inaccessible scale. This led to the emergence of replantation surgery and a broad range of free tissue transfers, fundamentally reshaping the management of head and neck cancer, breast reconstruction, limb salvage following trauma, amputation surgery, hand surgery and many other areas. These advances not only substantially improved functional outcomes and quality of life for patients, but also broadened treatment indications and altered clinical management pathways. It is reasonable to ask whether early adopters of microsurgery in the 1970s anticipated the magnitude of its eventual impact.

The trajectory of microsurgery provides a useful framework for considering the current emergence of robotic microsurgery. As with any previous technological shift, the introduction of robotic-assisted microsurgery has prompted concerns regarding cost, efficiency, learning curves and clinical necessity—particularly in an era increasingly shaped by value-based healthcare. These concerns are valid and warrant careful consideration. However, history suggests that transformative surgical technologies are rarely justified by immediate gains in speed or efficiency alone. Their enduring value lies more often in their capacity to expand the technical capability of surgeons and to redefine what surgeons are willing and able to do clinically.

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The role of robotic microsurgery

Robotic microsurgery should not be viewed as a replacement for surgical judgement, experience or foundational microsurgical skill. Rather, it represents an expansion of technical capability and an opportunity to expand the field of reconstructive surgery. Even the most experienced microsurgeons are constrained by intrinsic human limitations: physiological tremor, aging, fatigue, reduced precision at submillimetre scales, and diminishing endurance during prolonged or technically demanding procedures. These constraints are not a reflection of inadequate training or expertise; they are inherent to human physiology. Robotic platforms, through tremor elimination, motion scaling and enhanced stability, allow deliberate movement to be executed with a level of consistency and control that lies beyond the reliable capability of most microsurgeons when operating by hand alone.

This distinction is critical. The robot does not interact with the patient, nor does it determine what operation to perform or why. It does not replace clinical decision-making, anatomical understanding, reconstructive planning or the doctor-patient relationship. Rather, it enables the surgeon's intent to be executed with greater precision, particularly in technically marginal scenarios. This advantage is most evident in deep or confined operative fields and procedures involving very small calibre vessels and nerves (that is, super-microsurgical tasks), which increasingly define modern reconstructive practice.

Robotic microsurgery in Australia is not developing in isolation. Internationally, there is a clear and accelerating trend toward robotic integration across subspecialty disciplines, with a dedicated microsurgical robotic platform now commercially available and clinically deployed at multiple centres worldwide. Several other robotic microsurgical systems are under development with ongoing refinement and new instruments. In 2024 and 2025, approximately 12 major international plastic surgery meetings included at least one session focused on robotic microsurgery and the number of institutions with an established robotic microsurgical program has almost doubled. In this context, engagement with robotic microsurgery is less about adoption for its own sake and more about participation in an evolving global conversation. Those who engage early help shape indications, training frameworks, safety standards and appropriate use.

Australia has long maintained a high standard of medical care and has played a significant role in the early development of microsurgery, particularly in instrument design, clinical application and training of surgeons worldwide. In August 2024, the plastic surgery unit at St Vincent's Hospital Melbourne established a clinical robotic microsurgery program, the first of its kind in Australia and the Asia-Pacific region. This initiative reflects a deliberate institutional effort to engage early with emerging microsurgical technologies, evaluate their role within established reconstructive practice, and contribute thoughtfully to the broader evolution of the field. A broader collaboration between units with similar vision may help ensure that Australian plastic surgery remains internationally relevant in this rapidly evolving area.

Integration with established practice

Early global clinical experience suggests that surgeons exposed to robotic microsurgery are impressed by the degree of precision and control it offers. As expected with any new technology, initial implementation has been associated with logistical and workflow challenges as systems are integrated into daily practice. At several institutions, the introduction of the robotic system has led to the development and/or consolidation of subspecialty clinical services, particularly in lymphatic surgery. Perhaps more interesting was the observation that many surgeons, after engaging with robotic microsurgery, begin to re-evaluate their conventional surgical techniques, refine/alter established operative strategies, and actively explore how technology may enable greater consistency and technical confidence. This is particularly evident at this stage in the field of lymphoedema surgery and breast reconstruction.

After 12 months of clinical application at St Vincent's Hospital Melbourne, the most striking aspects of robotic microsurgery have been precision and control. The system is noticeably gentle on vessels, with more consistent and accurate suture placement. Repairs involving structures less than one millimetre in diameter, including lymphatic vessels, can be performed with a level of stability and confidence that is difficult to replicate manually. These observations are experiential rather than declarative, and they do not negate the effectiveness of conventional microsurgical techniques. Instead, they highlight how robotic assistance may complement established practice in selected contexts.

Traditional outcome measures such as flap survival or anastomotic patency may not immediately differ between robotic and hand-sewn microsurgery, particularly in experienced hands. However, outcomes alone may be an incomplete metric for assessing value at this stage of development. The potential impact of robotic microsurgery may lie in the ability to reliably address smaller vessels, reduce technical risk in borderline scenarios, improve consistency across long and complex cases, and expand indications in areas such as lymphatic surgery, peripheral nerve repair and free perforator flaps.

For the current generation of reconstructive microsurgeons—many of whom are beneficiaries of the microsurgical advances of the 1970s—there is a responsibility to recognise and responsibly explore technologies that may influence future standards of care. This does not require over-zealous enthusiasm or wholesale adoption. Rather, it calls for thoughtful engagement, honest evaluation and a willingness to consider whether emerging tools align with the principles that have historically advanced the specialty.

Extending this argument, it is worth considering how emerging technologies are perceived by younger microsurgeons and trainees. Many may be understandably hesitant to commit time and energy toward a direction that appears uncertain, particularly in a demanding training environment where mastery already requires significant investment. However meaningful progress in surgery has often depended on those with experience being willing to engage early with unfamiliar tools—not because outcomes were guaranteed, but because potential was recognised. Exposure to evolving technologies does not detract from foundational microsurgical training; rather, it may broaden perspective, encourage critical thinking and equip the next generation with the adaptability required to lead future advances in patient care.

Looking ahead

The future of robotic-assisted microsurgery is unlikely to be one of replacement. Conventional microsurgical skills will remain essential, and hand-sewn techniques will continue to define much of reconstructive practice. Instead, the immediate future is likely to be a hybrid model. As reconstructive practice increasingly extends into lymphatic surgery, complex nerve repair and minimally invasive perforator-based reconstructions, robotic systems serve as adjuncts that enhance stability and precision, broaden clinical applications and, potentially, improve the sustainability of complex microsurgical services.

In the future, robotic microsurgery is likely to extend beyond its current application of suturing small structures and evolve with other emerging technologies. Microsurgery (and surgery in general) will be defined by its integration with advanced imaging, simulation-based training, digital planning and artificial intelligence-assisted feedback systems to support technical safety, consistency and training.

Ultimately, the question is not whether robotic microsurgery is necessary today, but whether it represents a meaningful extension of principles that have already shaped modern reconstructive surgery. Microsurgery advanced because surgeons embraced tools that allowed them to see more clearly and operate more precisely. Robotic microsurgery represents a continuation of that same philosophy—one that warrants careful consideration, measured adoption and ongoing dialogue within the profession.

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