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"To Err Is Human…"—Managing Human Error in Reconstructive Microsurgery Training with Defense Barriers

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Error is an unavoidable part of normal human behavior. Surgery requires manual dexterity, and related human factors, including error, may affect patient outcomes.[1] Microsurgery is a highly technical surgical subspecialty, requiring a demanding manual skill set and complex intraoperative, and perioperative decision making. Technological advances including higher magnification, finer instruments, coupling devices, and improvements in suture quality, have expanded the role of microsurgical techniques across several surgical specialties.

According to Rasmussen's error level model, surgery can be examined in relation to error and accountability. In reconstructive microsurgery, negotiation of a steep learning curve is highly depended on regular, deliberate practice of specific, generally technical, tasks. However, errors in microsurgery might be classified as skill-, rule-, or knowledge-based. Skill errors relate to surgical execution and are largely dependent on the surgeon's technical competency. Rule errors are related to surgical planning and are more common in experts. Knowledge errors are generally unconscious problem-solving mistakes in surgical decision making, and more common in juniors. Cuschieri[2] described a model of reasoning for laparoscopic surgical errors and demonstrated the importance of defense mechanisms to prevent active and systematic errors.

In surgical training, a trainee is expected to reach specific performance standards before operating independently. Traditionally, this was achieved using the Halstedian apprenticeship model. However, simulation training now plays a major role, especially in traversing early learning curves. Analysis of common errors will allow defense barriers to be incorporated into education and training to enhance: microsurgery skill, for example, microvascular anastomosis, perforator dissection, flap elevation and inset; microsurgery planning in the context of supervised clinical service provision; and knowledge in the context of a rapidly changing evidence base and practice.

Microsurgical procedure errors can also be analyzed into errors in the execution of skill-based tasks and in execution of rules and knowledge (Table 1). We have described common microvascular anastomotic technical errors,[3] which predict surgical outcomes failure, and lend themselves to establishing thresholds in training progression.[3,4] Rule and knowledge errors have attracted less attention. Here, defense barriers could be built using the deconstruction approach behind the global rating scores already used in objective microsurgical skill assessment.

Table 1. Types of Errors in Reconstructive Microsurgery, Definitions, and the Development of Defense Mechanisms

Errors in Microsurgery	Definition	Opportunities to Develop Defense Barriers
Skill	When the skill-set or surgical actions are not automatic or don't "come naturally" - stored cognitive patterns of preprogrammed instructions.	Within deliberate simulated practice, objective assessment tools such as: global rating scales, end product assessments, and hand motion analysis.
Rule	Errors occur in a rule-based cognitive mechanism—competency without requiring a great degree of thought.	Structured work-based clinical immersion within training programmes and clinical fellowships including multidisciplinary team exposure.
Knowledge	Errors occur in an unfamiliar surgical task, with a greater degree of thought, as a surgeon attempts a problem-based solution in a surgical task not previously performed.	Didactic exposure to principles and novel approaches within training schemes and postgraduate degree programmes.

This communication aims to support more structure to microsurgery education and training, including defense barriers in nonthreatening environments, in the interests of safe and excellent clinical outcomes.

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