

Development and Comparative Evaluation of Computer-based Assessment Tools for Manual and Robotic Microsurgery

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Background

Microsurgical evaluations are invaluable for **microsurgical skill development**, however, time- and personnel demanding. The concept of robotic-assisted microsurgery raises microsurgical training requirements of un-/experienced microsurgeons to a new level. This study aimed to develop efficient and reliable tools for **microsurgical self-assessment**, applicable to both **conventional and robotic-assisted microsurgery**.

Material & Methods

Development of two deep convolutional neural network-based computer algorithms:

1. Microsurgical instrument tracking

- video analysis
- supervised and semi-supervised learning used to train models

2. Anastomosis quality assessment

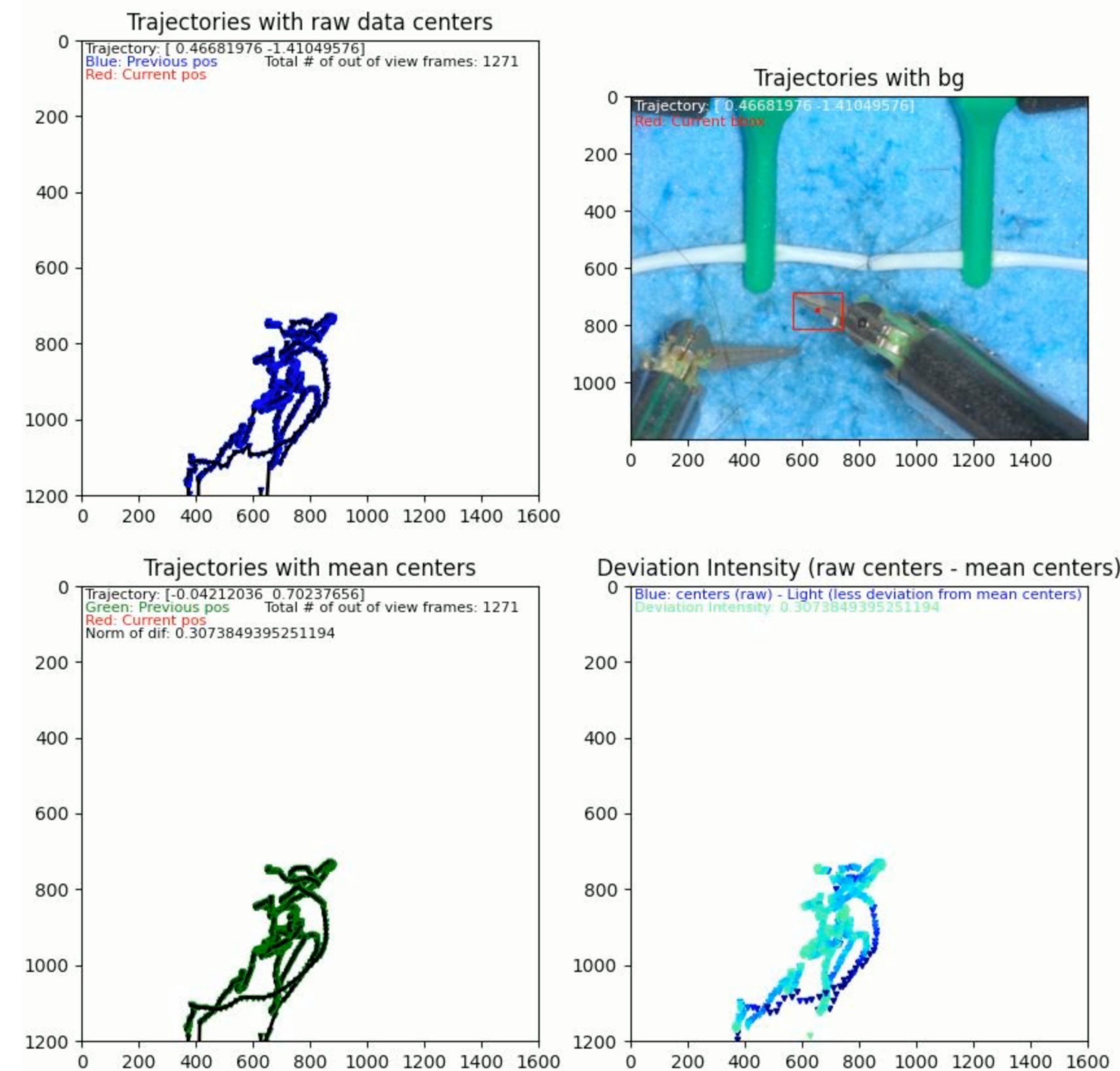
- trained computer algorithm
- analysis of everted anastomosis images
- Total training images: 90 manual and 90 robotic anastomoses (1.0 mm Ø silicone vessels (WetLab, Japan); 10-0 sutures)

Results

Microsurgical Instrument Tracking

Deep learning model provides:

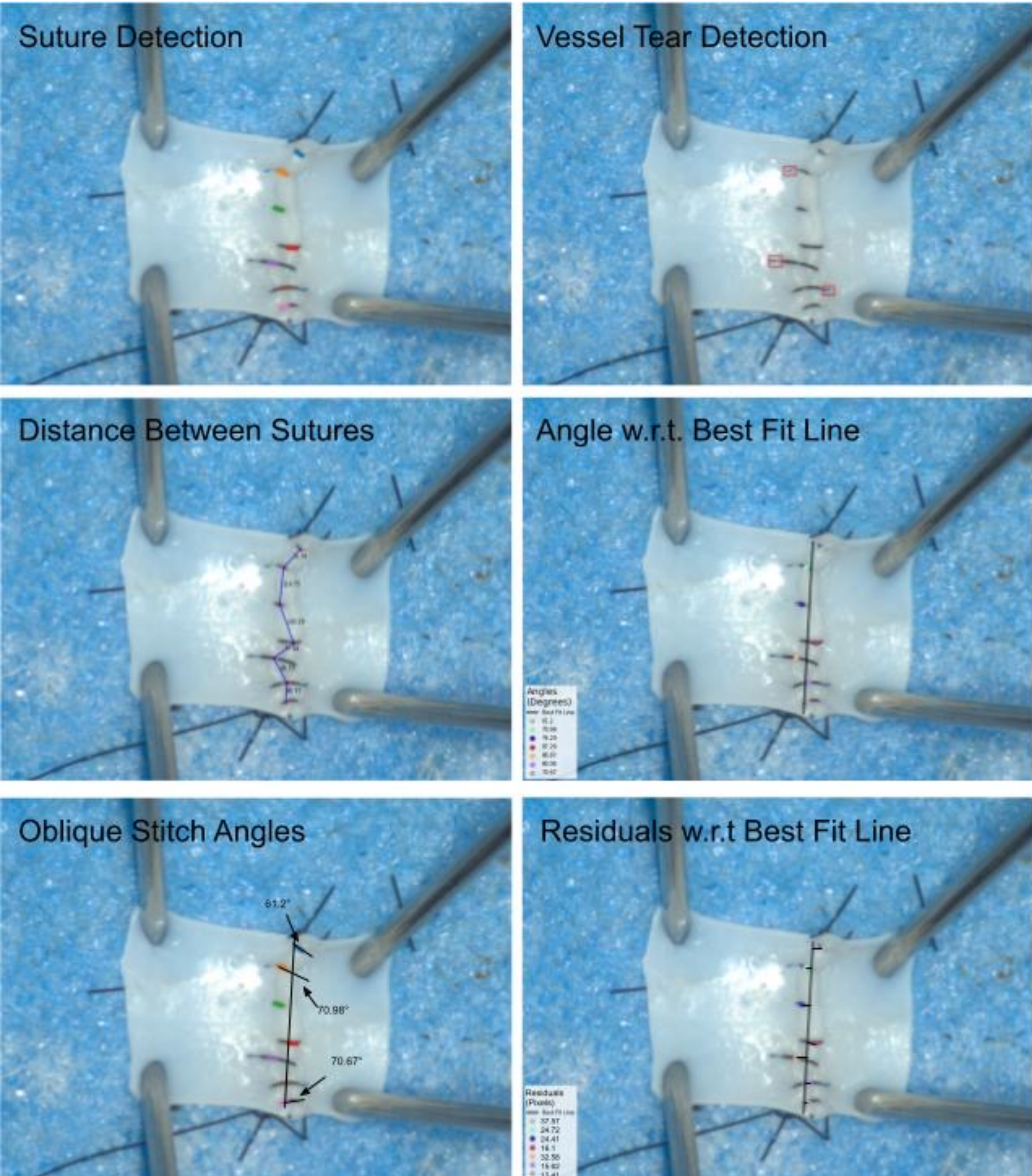
- **Trajectory** of microsurgical instrument movements (video)
 - **Efficacy** = total trajectory length/time per anastomosis
 - **Out of view counts**
- **Tremor** (absolute deviation from smooth trajectory)
 - **Average Deviation Intensity:**
 - **Robotic: 6.4 pixel**
 - **Conventional: 24.6 pixel**



Anastomosis Quality Assessment

Parameters analyzed by computer algorithm:

- **Number of stitches**
- **Disruptions of anastomosis line**
- **Unequal distancing between stitches**
- **Oblique stitches causing distortion**
- **Visible tears in vessel wall**



Work in progress

- **Internal validation (IV):**
 - First IV: Mean average precision of ~0.80
 - Second IV: in progress
- **External validation**
- **Error definition**
- **WebApp development & pilot study**

Conclusion

We developed **two completely automated algorithms** for microsurgical self-assessment, promising to markedly **increase accessibility and practicability of feedback-based microsurgical training**. Both models are trained and evaluated in conventional and robotic microsurgical settings, therefore holding **great potential** to further **leverage and accelerate robotic evaluation and training in microsurgery**.

References

Chan W, Niranjan N, Ramakrishnan V. Structured assessment of microsurgery skills in the clinical setting. *J Plast Reconstr Aesthetic Surg.* 2010;63(8):1329-1334. doi:10.1016/j.bjps.2009.06.024

Ghanem A, Al Omran Y, Shatta B, Kim E, Myers S. Anastomosis Lapse Index (ALI): A Validated End Product Assessment Tool for Simulation Microsurgery Training. *J Reconstr Microsurg.* 2015;32(03):233-241. doi:10.1055/s-0035-1568157

Milling R, Carolan D, Pafitanis G, Quinlan C, Potter S. Microtools: A systematic review of validated assessment tools in microsurgery. *J Plast Reconstr Aesthet Surg.* 2022 Nov;75(11):4013-4022. doi: 10.1016/j.bjps.2022.06.092. Epub 2022 Jun 29.