

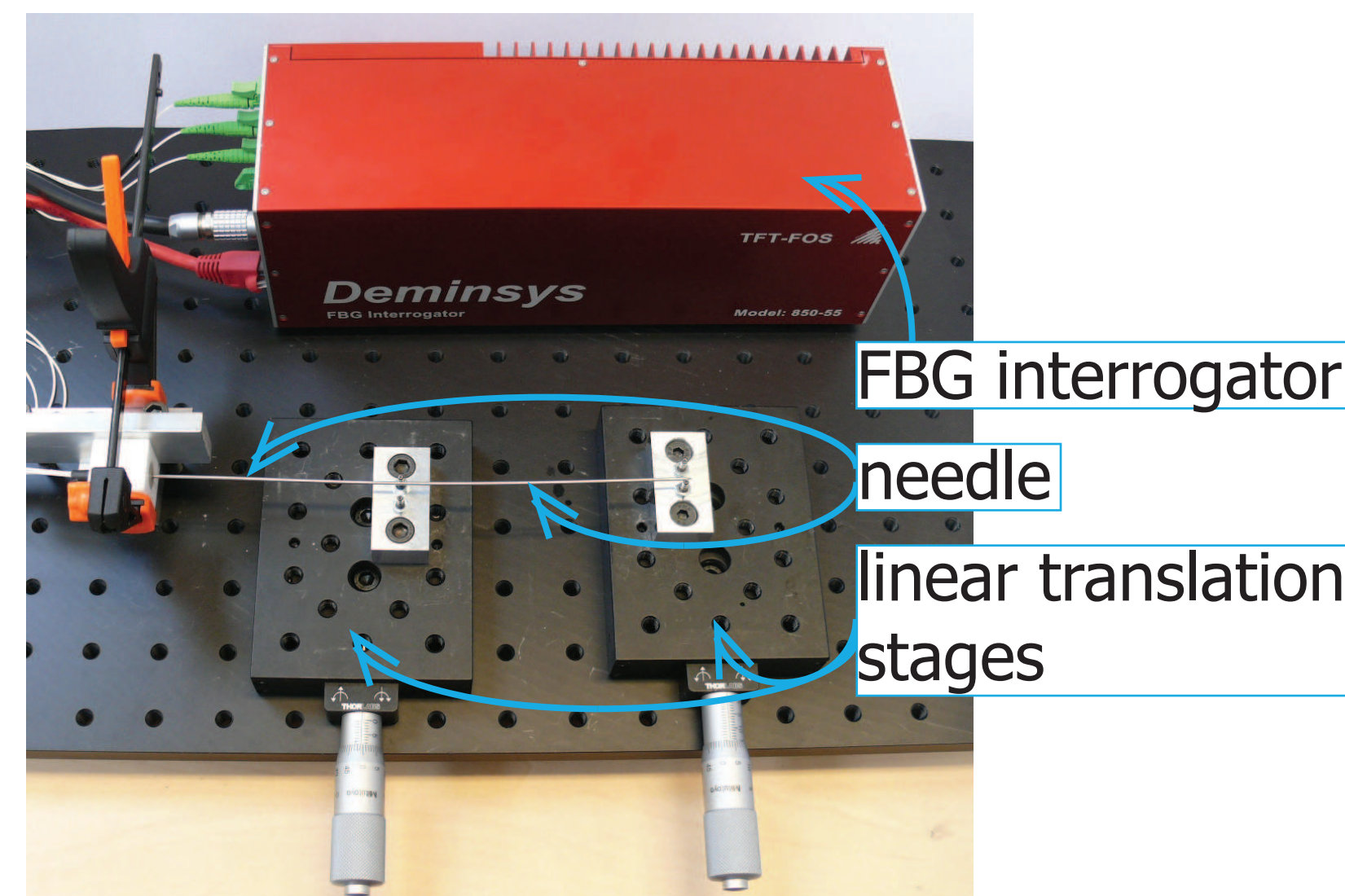
Strain sensor configurations for needle tip position estimation

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Introduction

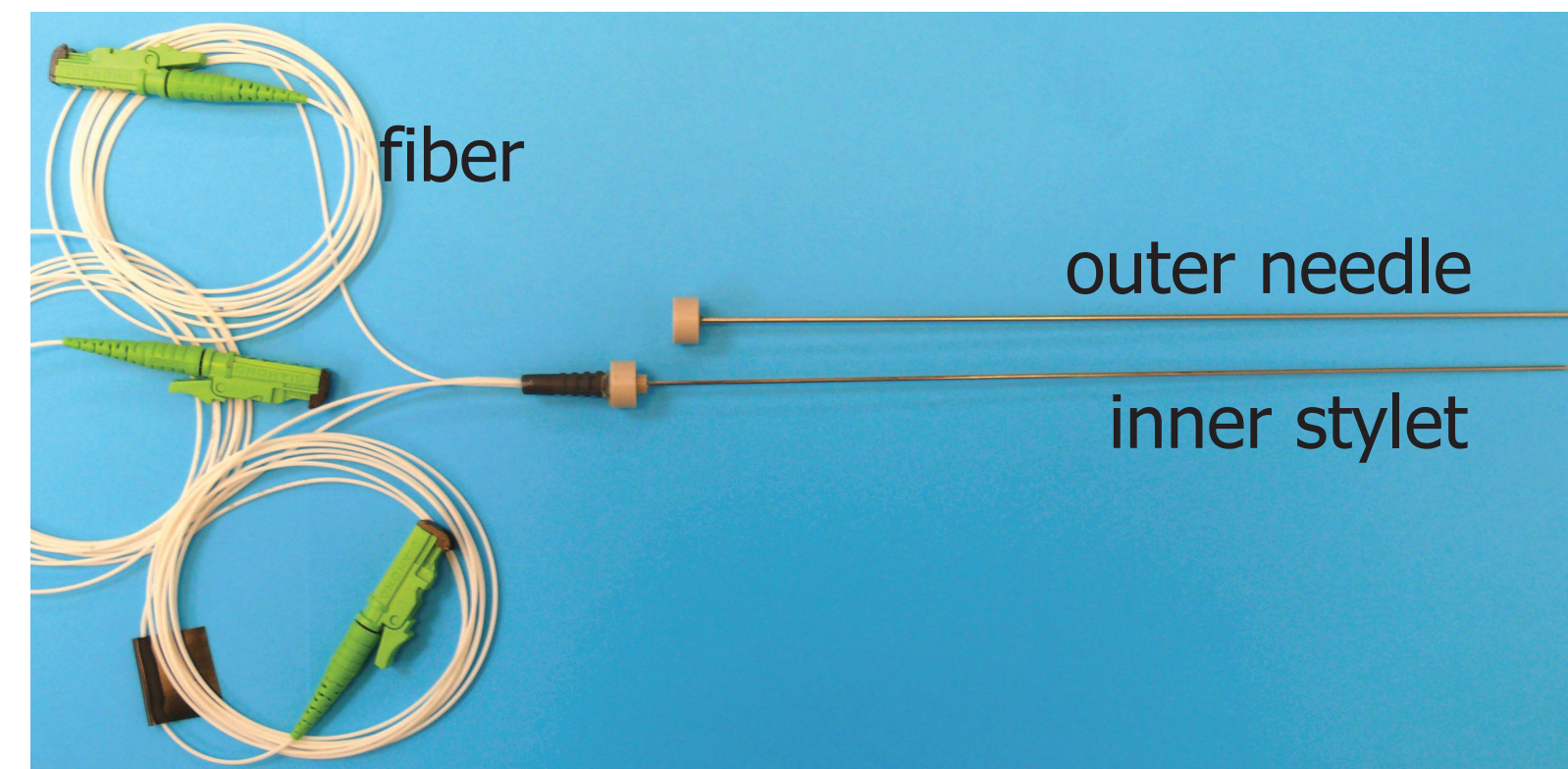
- Accurate placement (< 2 mm) of the needle tip contributes to the success of a treatment such as radiofrequency ablation of liver tumors.
- Deflection of the needle during insertion in tissue complicates positioning of the needle tip.
- Robotic steering may improve accuracy of positioning, but requires information about the needle shape.
- Needle shape can possibly be estimated based on strain measurements with fiber Bragg gratings (FBGs).
- Aim:** Determine the errors in estimating needle tip position based on FBG measurements. Two needles with different sensor configurations (number and position) were tested.

Measurement set-up



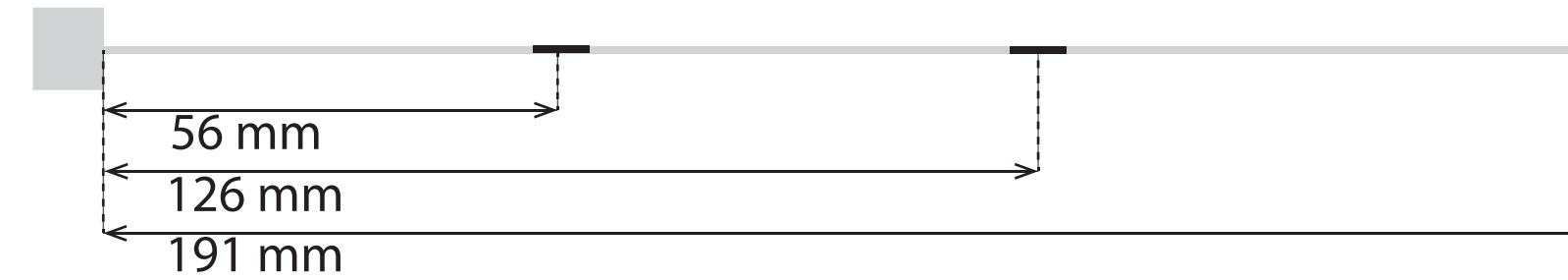
- Displacements ranging from -12.5 mm to 12.5 mm are applied at the tip (1 deflection), or at the tip and middle (2 deflections) of the needle by moving the translation stages.
- The output of the FBGs is measured with an interrogator (Deminsys, Technobis) and saved.
- Shape and tip position are calculated offline based on geometry.
- Estimated tip position is compared to the displacement applied at the tip.

Sensorized needles

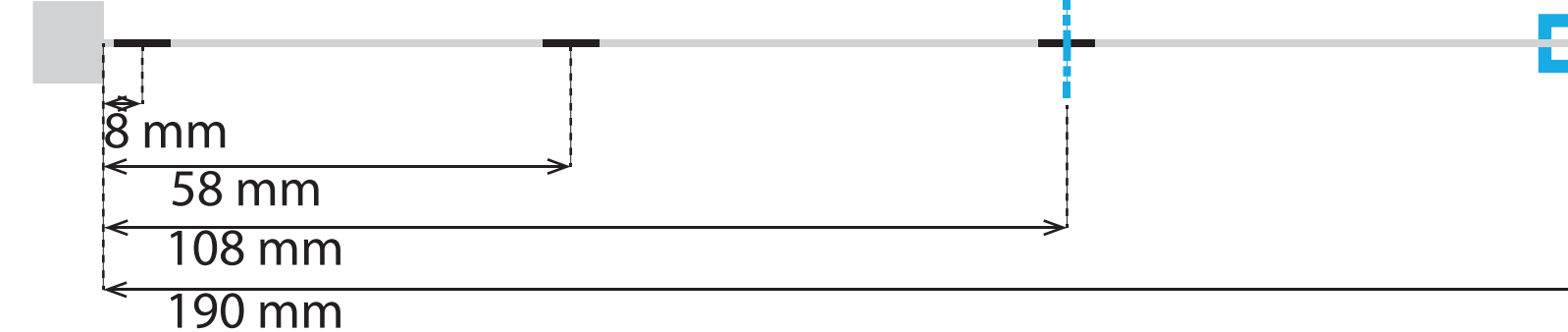


18G/20cm trocar needle (Cook Medical) with integrated optic fibers equipped with fiber Bragg gratings (FBGs)

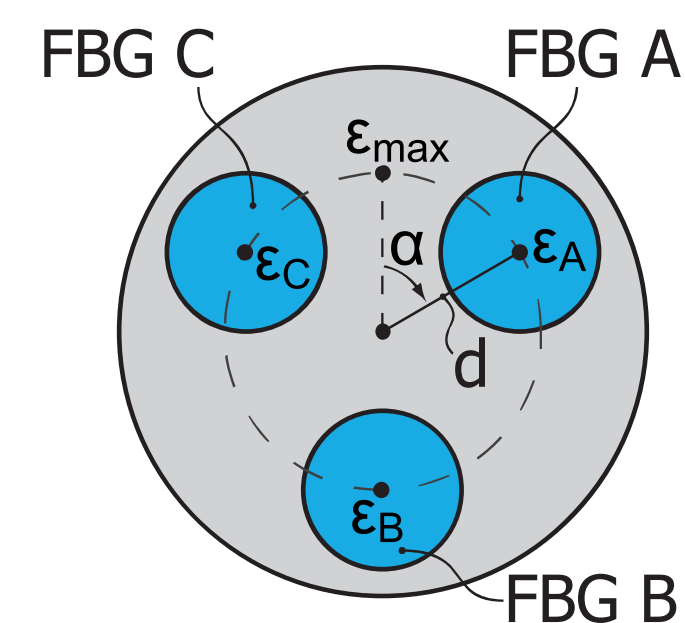
Needle 1 (2x3 FBGs)



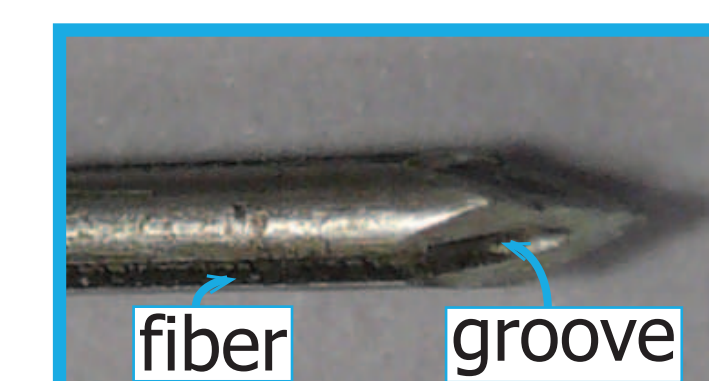
Needle 2 (3x3 FBGs)



Cross section A

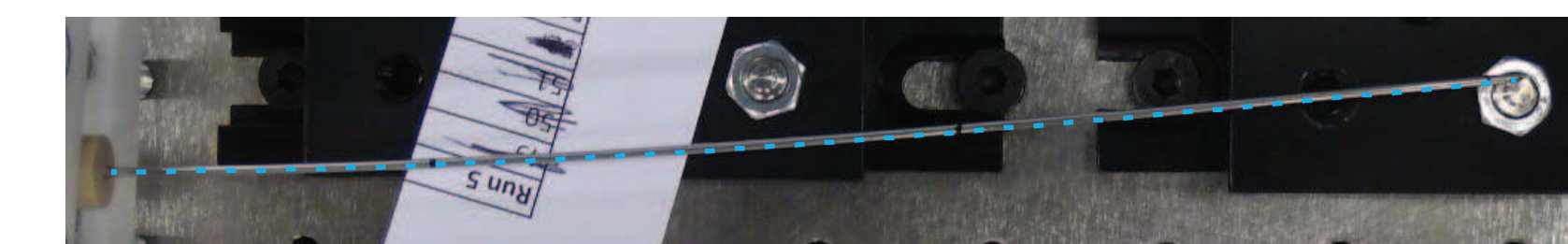
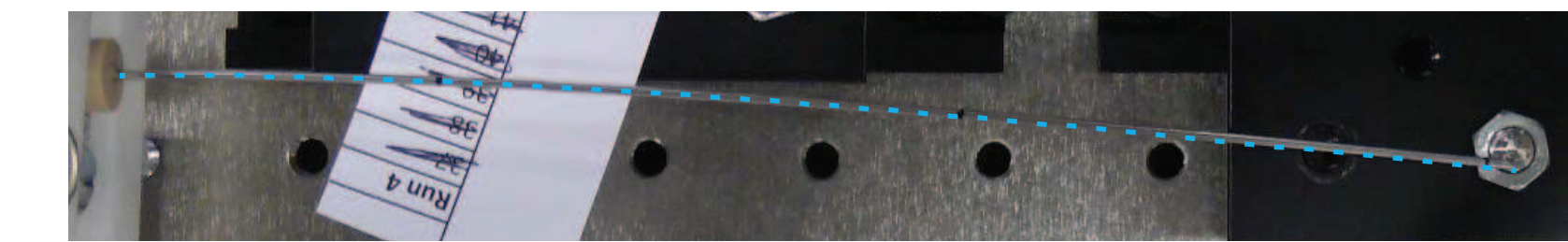


Magnification B: needle tip

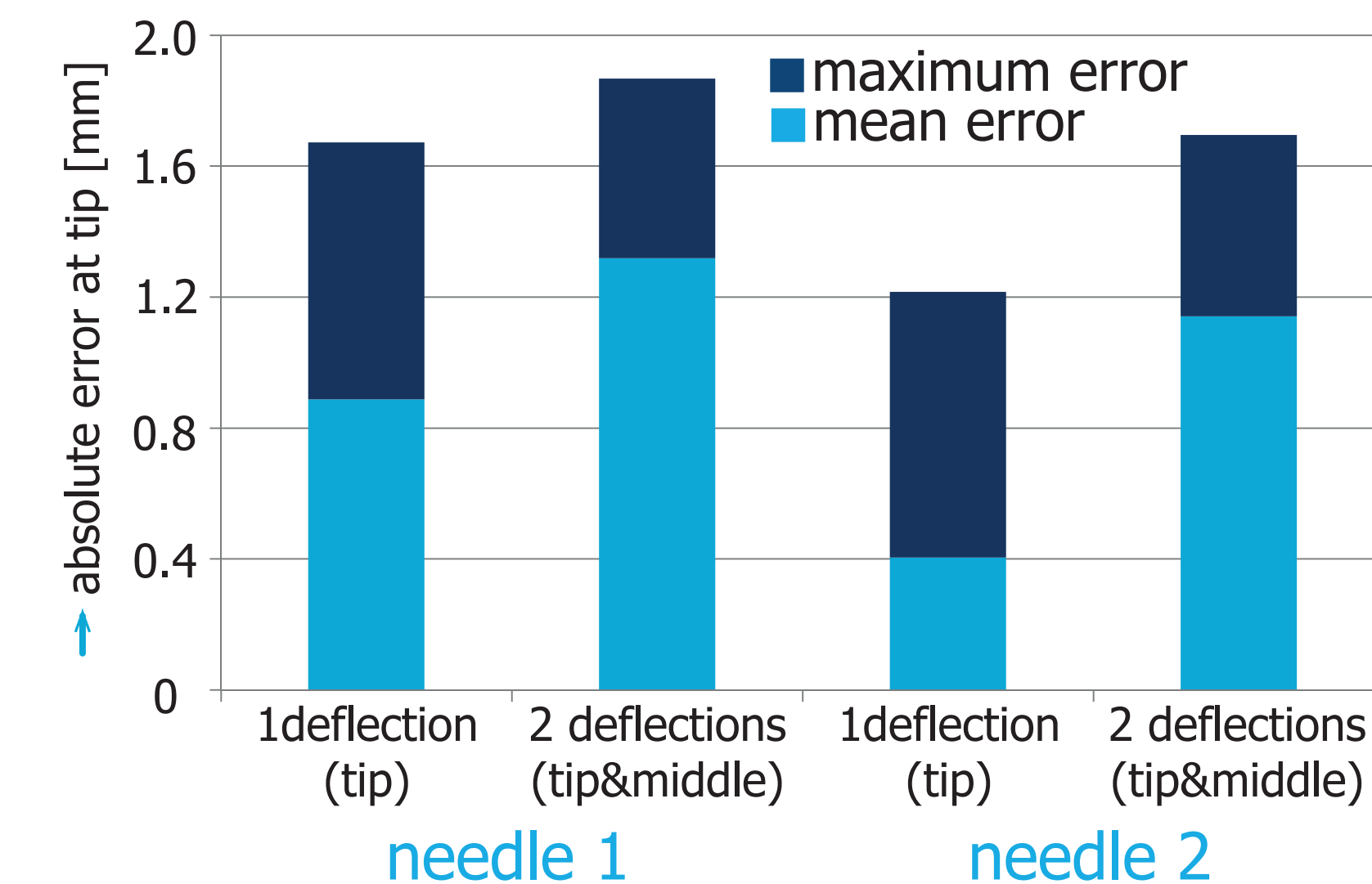


Results

Shape estimation



Error in estimation of tip position



Conclusion

- Errors in estimated tip positions are smaller than 2 mm, which corresponds to clinical requirements.
- Adding FBGs results in error reduction, but the needle with two FBG positions already provides sufficient accuracy.