

Effect of a thin-tipped short bevel needle for peripheral intravenous access on the compressive deformation and displacement of the vein: a preclinical study

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INTRODUCTION

Peripheral venous puncture in patients with difficult venous access (DIVA) often fails on the first attempt.¹ Risk factors for the failure include small vein size and dehydration², causing vein deformation and displacement due to puncture resistance of the vessel.

OBJECTIVES

A 22-gauge PIVC with a short, thin-tipped bevel needle was developed ³, and we compared its puncture performance with four types of commercially available 22-gauge PIVCs using an *ex vivo* model for evaluation of compressive deformation and displacement during needle insertion.

CONCLUSIONS

The PIVC with the thin-tipped short bevel needle showed significantly lower compressive deformation and displacement of the vein than the conventional PIVCs. This needle has the potential to improve the first-attempt success rate of peripheral intravenous catheterization in DIVA patients.

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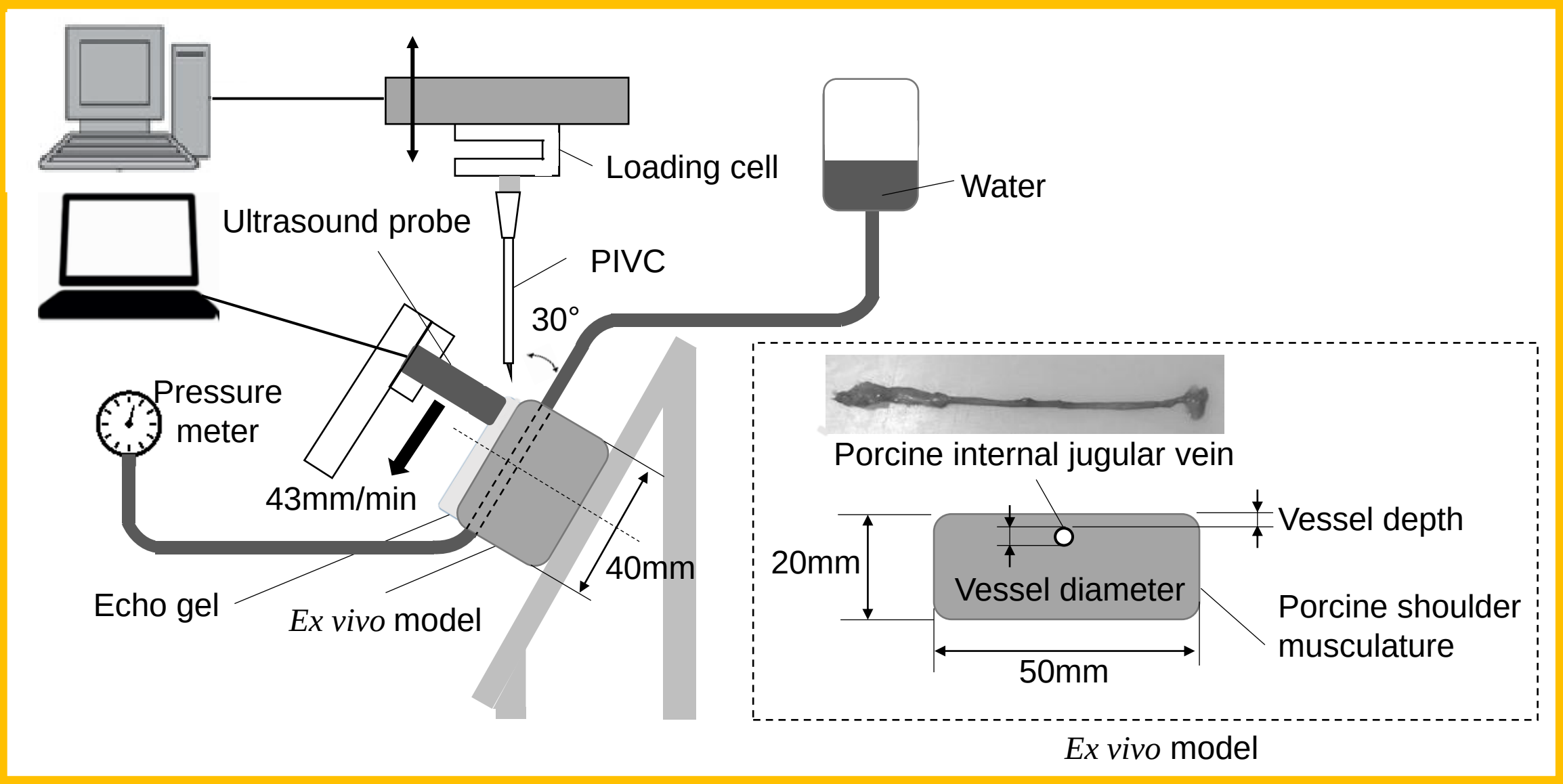
METHODS

Ex vivo model

The *ex vivo* model was prepared by combining a porcine shoulder and porcine internal jugular vein to simulate the cephalic vein of the human forearm. We positioned the blood vessel with a diameter of 2.7–3.7 mm and placed it at a depth of 2–5 mm. Since the peripheral venous pressure of the human forearm is 1.7 ± 0.5 kPa ⁴, the porcine vessel was filled with water produced with a hydrostatic pressure of 1.3 kPa.

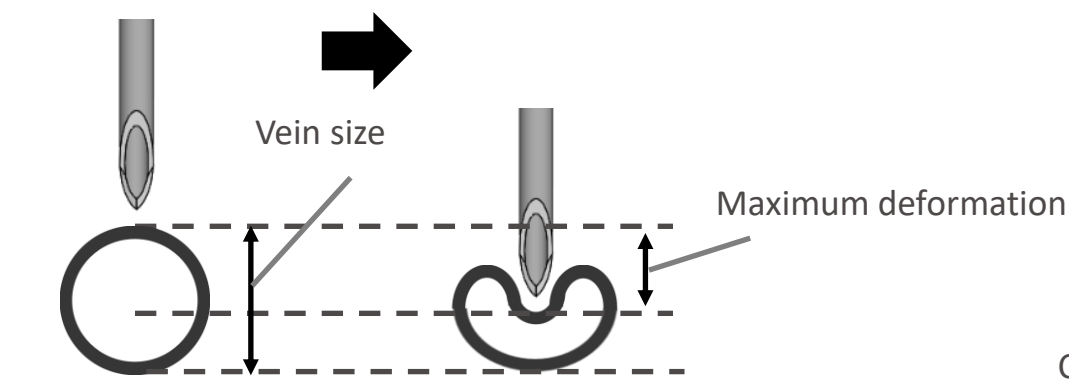
Compressive deformation rate and displacement of the vein

The *ex vivo* model was set on a jig to allow a puncture angle of 30°, and the PIVC was attached to the load cell of the compression testing machine (AGS-1kNX, Shimadzu Corporation, Kyoto, Japan). The puncture speed was set at 50 mm/min. The test was started before the vessel was punctured and ended when the needle passed through the posterior wall of the vessel. Vein deformation and displacement were observed by ultrasound (eZono-4000, Jena, Germany) and calculated by using Image J software (version 1.53a).

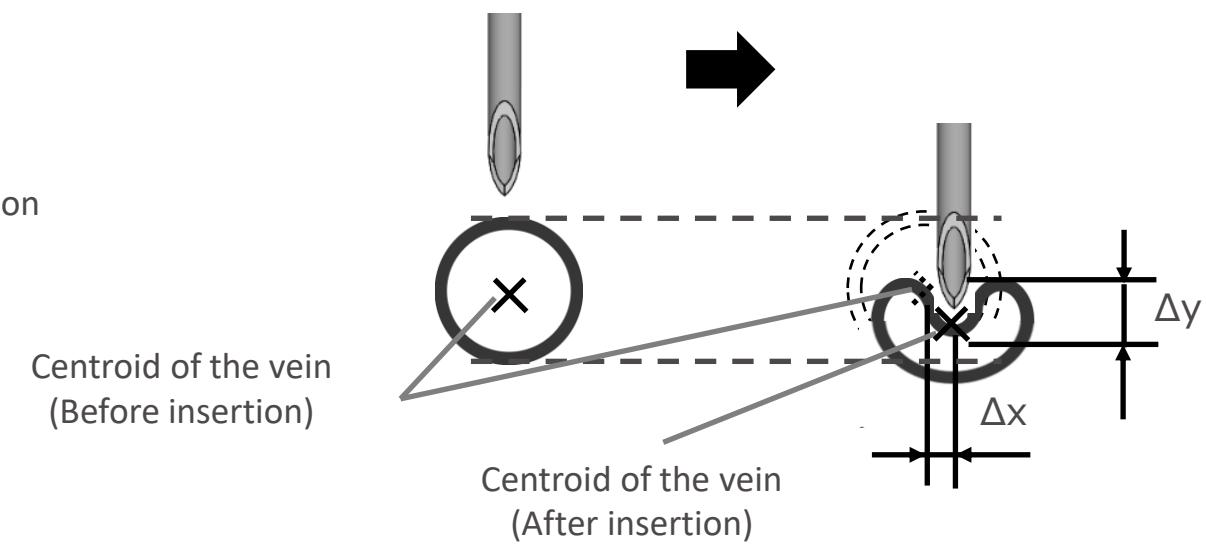


Schematic images of the outcomes

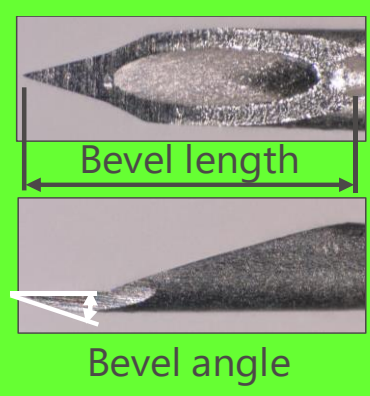
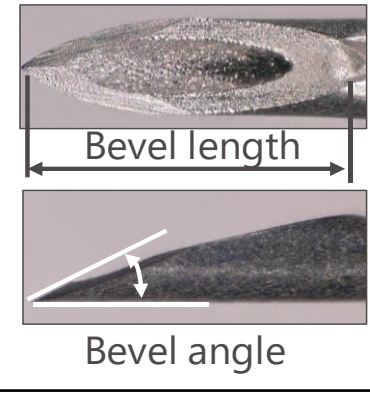
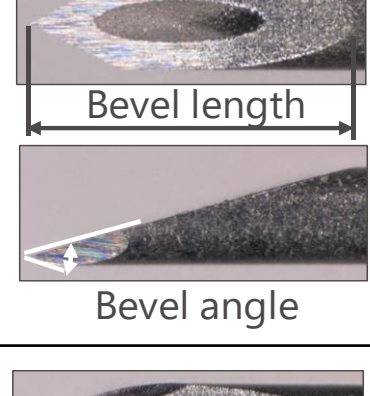
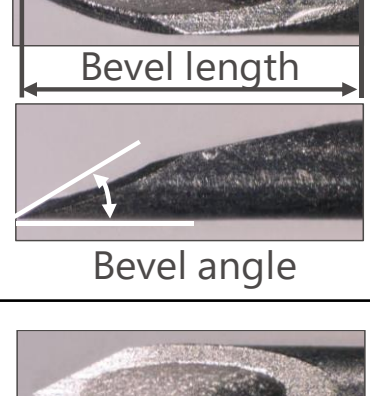
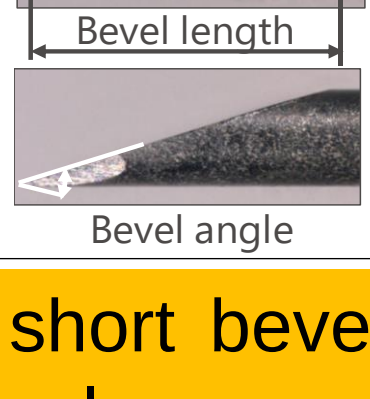
Compressive deformation rate
 = Maximum deformation / vein size



Vein displacement
 = Changes in the centroid of the vein during needle insertion



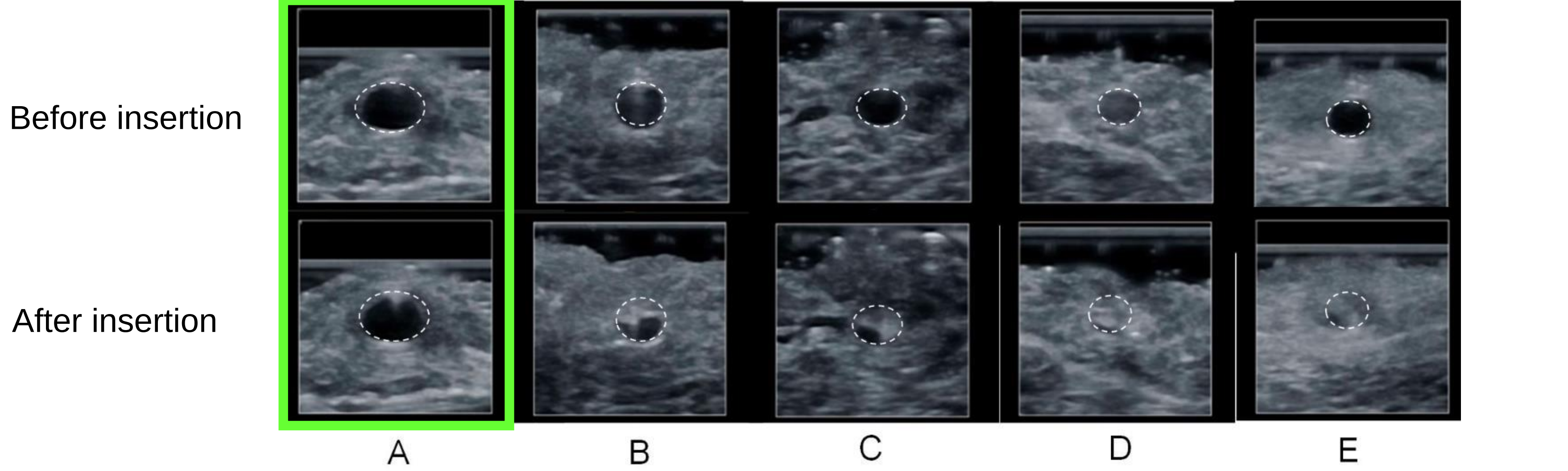
Images of the needle tips

Sample name	Geometric design of the needles	Bevel length, mm	Bevel angle, degrees
A: PIVC* with the thin-tipped short bevel needle * Same structure as B except the needle		1.9	22
B: Surshield Surflo 2 (Terumo)		1.9	26
C: SuperCath 5 (Medikit)		1.8	43
D: Insyte Autoguard BC (Becton Dickinson)		1.8	32
E: Introcan Safety 3 (B. Braun)		1.6	39

The thin-tipped short bevel needle (A) has the smallest bevel angle.

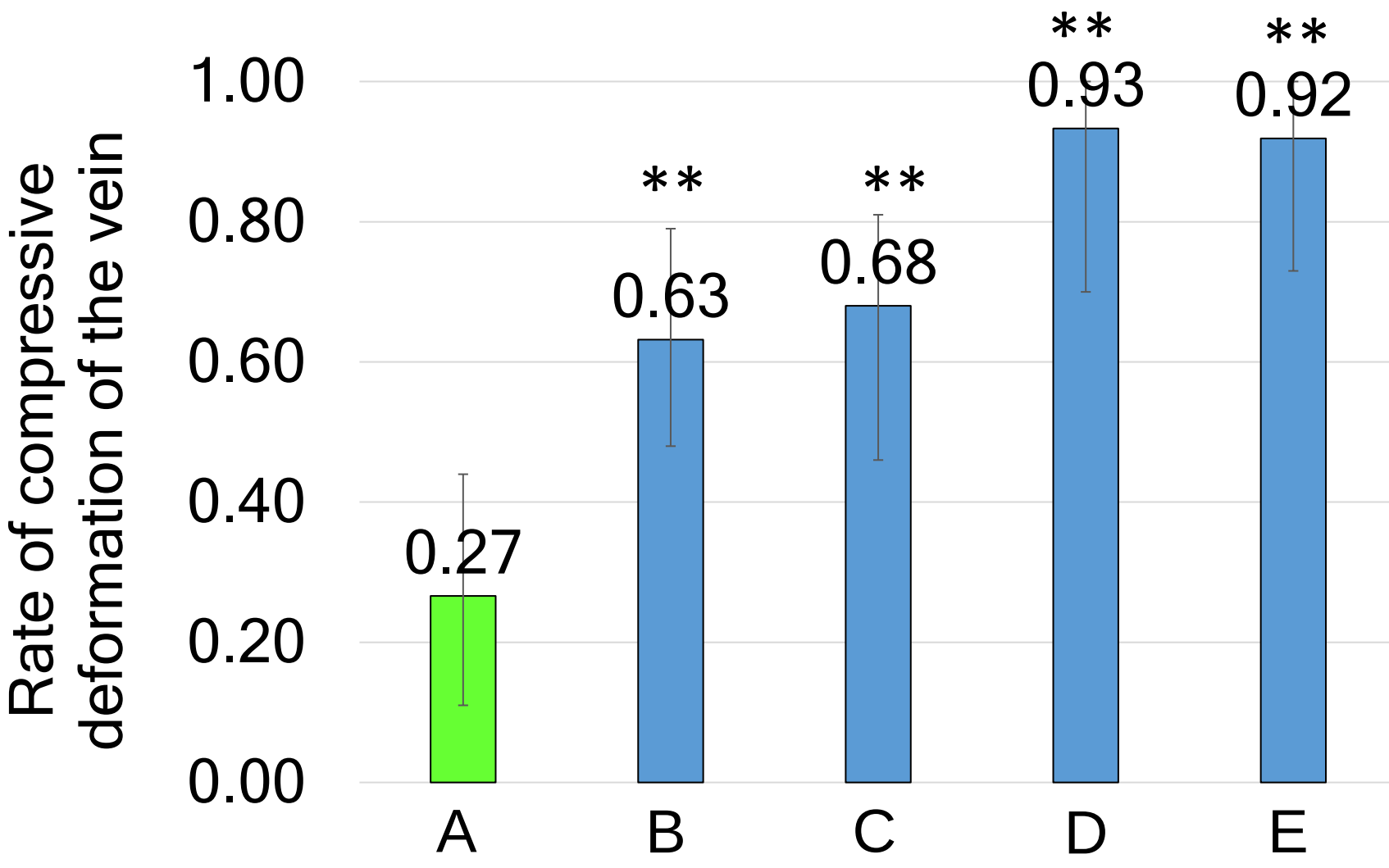
RESULTS

Ultrasound images before and after the PIVCs insertion



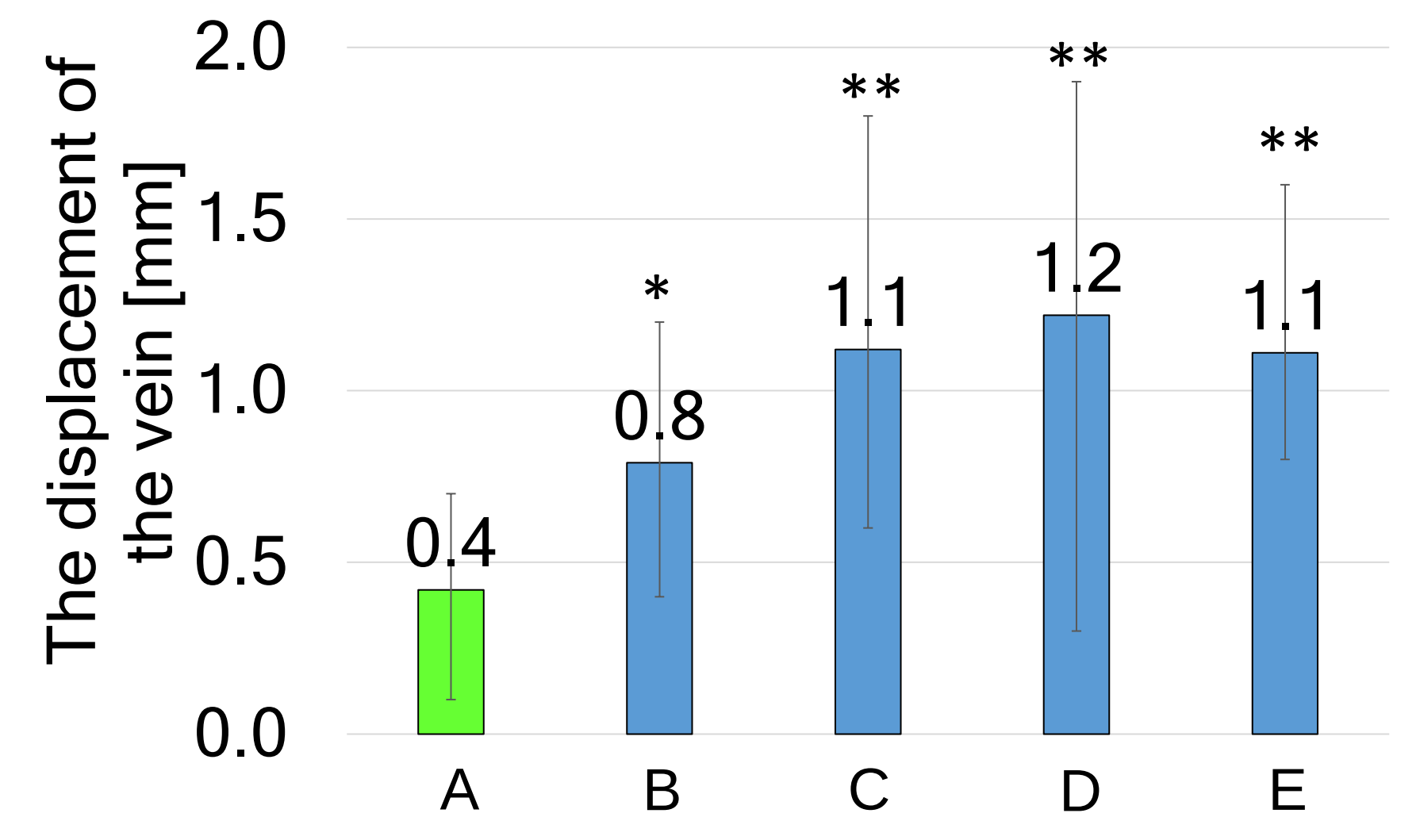
Rate of vein deformation

Average ± SD (N=10)



Vein displacement

Average ± SD (N=10)



PIVC with the thin-tipped short bevel needle (A) was associated with significantly lower compressive deformation rate and venous displacement compared to the other four PIVCs.

DISCUSSION

- This is the first study to create an *ex vivo* model simulating the peripheral vein of the human forearm using animal vein and tissue, and to compare the deformation and the displacement when punctured with a PIVC having a thin-tipped short bevel needle and four other PIVC.
- The thin-tipped short bevel needle having the smallest bevel angle (22°) showed significantly smaller deformation and displacement of the vein compared to the conventional PIVCs.
- Our results suggest that the thin-tipped short bevel needle may be effective in improving the first attempt success rate in patients with difficult venous access by reducing the deformation and displacement of the vein.
- Further studies are needed to prove the effectiveness of this needle in clinical situations.