Tactile Feedback for Needle Insertion Accuracy: A Comparison of Three Types of Intraosseous Access Devices

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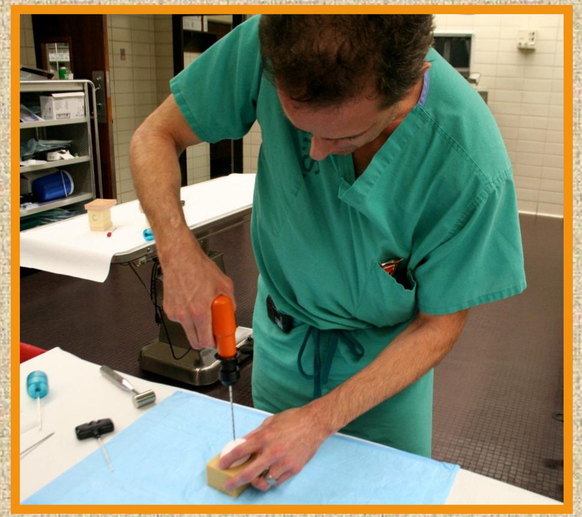
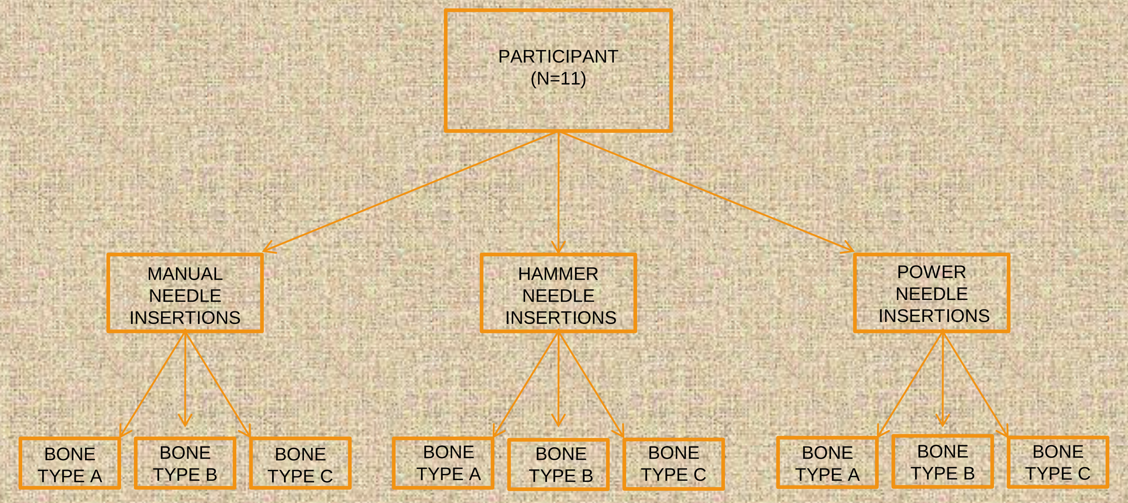
Introduction

Intraosseous (IO) needle placement is often used for vascular access as an emergent alternate to peripheral venous access and additionally for applications such as bone marrow sampling and vertebroplasty. For over 85 years clinicians have placed IO needles into bone using either the manual technique of twisting and pushing or hammering with varied results. Within the last decade rotary powered IO devices have been introduced offering the clinician a third method of IO access. Increased awareness of this technology has raised questions concerning device control and the ability of clinicians to discern needle tip location within the bone while relying on tactile feedback. Tactile feedback has been widely accepted as the predominant method of discerning correct IO placement in most clinical settings, especially those required in emergent medicine. This study was designed to determine the relative precision of needle placement using only tactile feedback. This study additionally assessed the ability of each insertion method to access simulated osteoporotic bone without damage.



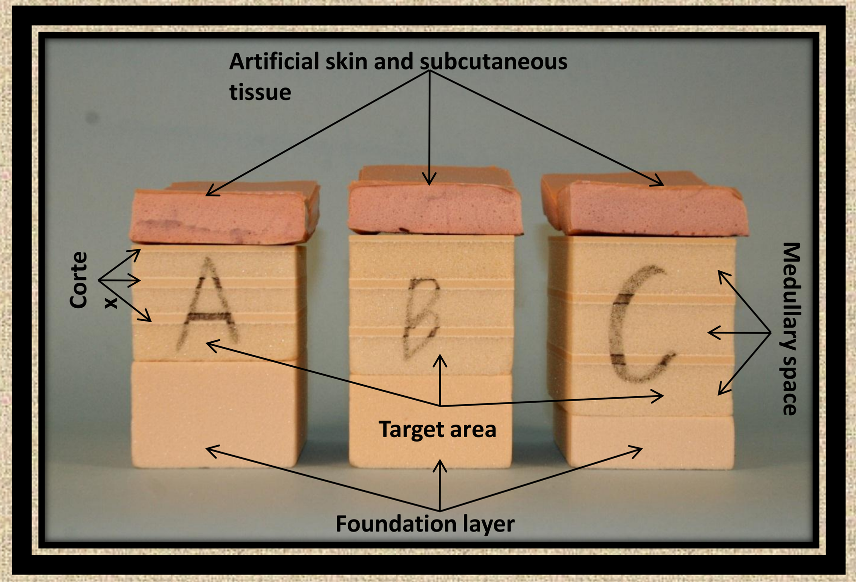
Study participants utilizing various IO insertion techniques



Randomized bone selection pathway for each IO insertion method

Materials and Methods

Three 11-gauge needles (manual, hammer-assisted and rotary power-driven) were inserted into simulated human bone by 11 participants. The total thickness of each simulated bone was 9cm, with each specimen consisting of 3 layers of simulated compact bone and 3 layers of cancellous bone. Each specimen consisted of 3 layers of simulated bone with an additional artificial skin and subcutaneous overlay further simulating the varied resistance encountered with human insertion. Lastly, a foundation layer of cancellous material was placed beneath the test layers to compensate for the different thicknesses of the test medium and provide space for the needle tip to extend if over-penetration occurred. Blocks were draped to prevent any visual bias from the study participants. Time was measured in seconds and commenced at the beginning of bone insertion, and ending when the participant indicated the needle had been placed in the target area. Participants rated perceived accuracy of insertion on a 0-10 scale. Placement accuracy was assessed by radiology and results were classified as either success or failure. Success was defined as the needle tip residing in the correct test block layer. Any other placement was a failure. Participants also inserted needles into raw eggs, simulating osteoporotic bones. Ability to place the needle without shell damage was assessed.

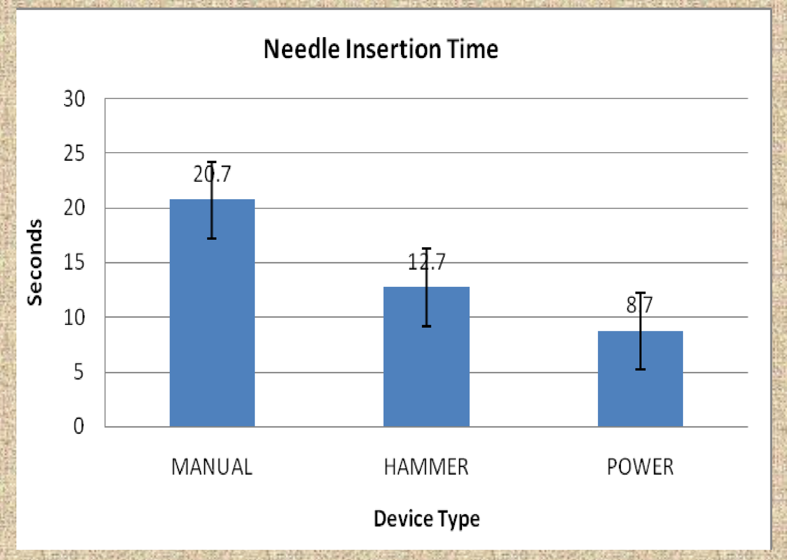


Simulated bone specimens specifically designed to determine\ participants ability to utilize tactile feedback for correct placement

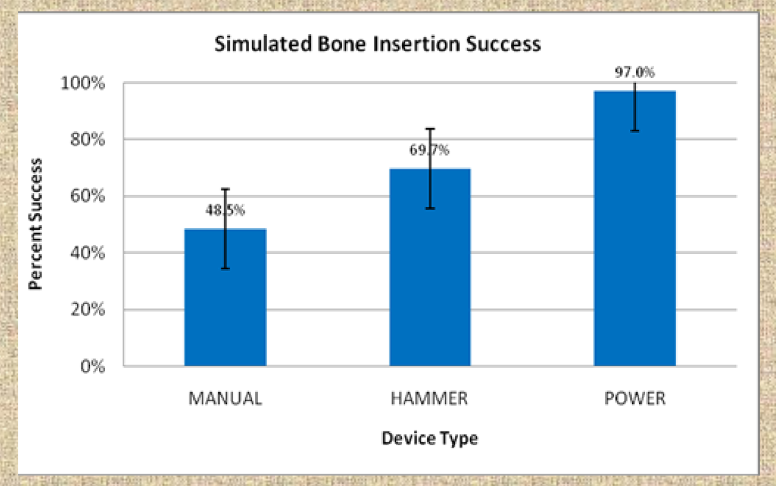
Correct IO placement was determined radiologically for each insertion

Results

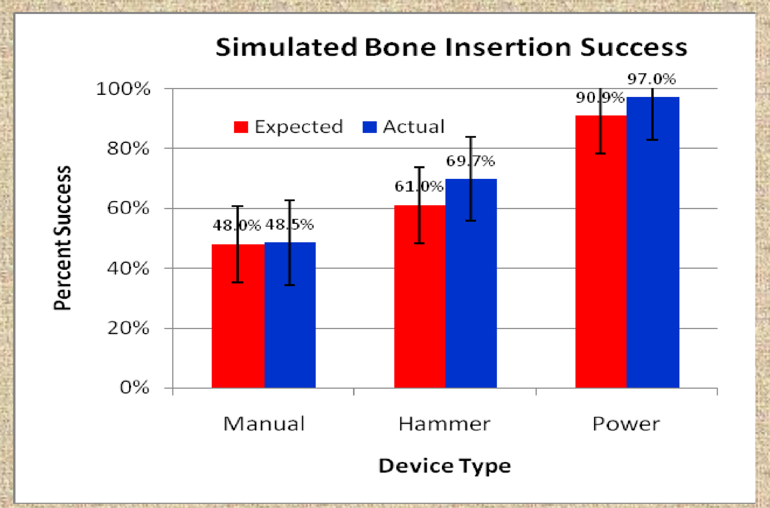
In simulated human bone, mean insertion times in seconds were: Manual 20.7±10.1, Hammer 12.7±5.9, Power 8.7±2.8. Differences were significant (p<.001).



Insertion success was: Manual 48.5%, Hammer 69.7% Power 97.0%; statistically significant (p<.001).

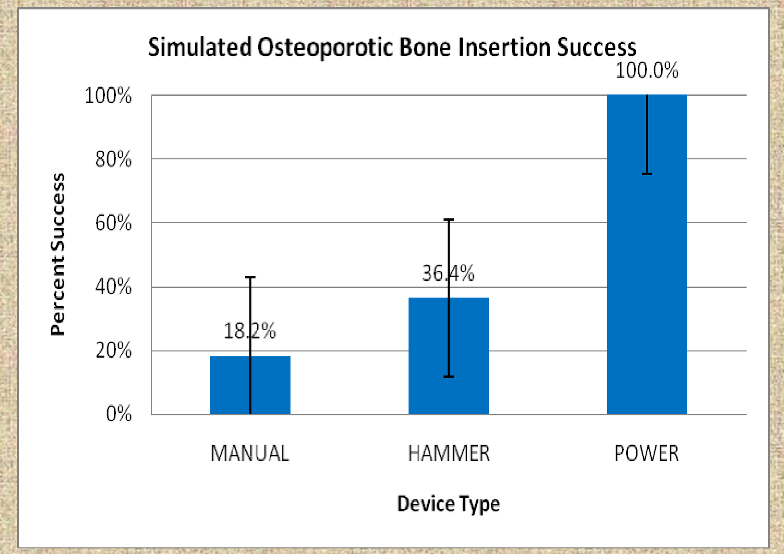


Mean insertion certainty levels were: Manual 48% Hammer 61%, Power 91%; statistically significant (p<.05).



Results

Simulated osteoporotic bone insertion rates (without damage) were: Manual 19.2%, Hammer 36.4%, Power 100% statistically significant (p<.001).



Conclusion

Using only tactile feedback, the rotary power-driven device may allow successful IO needle placement with improved success and confidence when compared to manual or hammer-assisted devices. Rotary power insertion may facilitate penetration into fragile bones without damage. These study results suggest that rotary powered IO placement may offer suitable tactile feedback for IO needle placement. The study further supports the relative safety of IO placement in simulated osteoporotic.

References

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