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Feasibility of Distal Femur Intraosseous Access in Adult Trauma: An Evaluation of Needle Length

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ABSTRACT

Objectives: Rapid vascular access is essential in trauma resuscitation, with intraosseous (IO) access providing a reliable alternative when peripheral intravenous access is not feasible. While the proximal humerus, tibia, and sternum are food and drug administration -approved IO sites, the distal femur has been proposed as a potential alternative, particularly in out-of-hospital adult cardiac arrest scenarios. This study aims to assess the feasibility of distal femur IO access in adults by evaluating the required needle length.

Methods: A prospective observational case series study was conducted involving 100 healthy adult volunteers. Ultrasound was used to measure soft tissue depth 2 cm proximal to the superior border of the patella. Measurements were taken with the transducer placed lightly on the skin and with gentle downward pressure. Participants with a skin-to-bone depth greater than 40 mm were considered at high risk for insertion failure, as the longest standard IO needle measures 45 mm.

Results: One hundred participants were enrolled, with a median age of 27.3 years (IQR 25.0–29.0); 64 (64.0%) were male. Body mass index ranged from 17.42 to 35.26 kg/m², with a median of 22.86 kg/m² (IQR 20.81–25.03). The mean soft tissue depth at the distal femur site was 25.0 mm (IQR 21.9–29.6) without pressure and 14.0 mm (IQR 12.0–16.0) with gentle pressure. No participant had a soft tissue depth exceeding 40 mm.

Conclusions: Distal femur IO access appears to be a feasible alternative for vascular access in young, non-obese adult patients. Our findings suggest that standard IO needle lengths are adequate for this site in this population, supporting its potential incorporation into emergency protocols. Further research is recommended to validate these results and inform standardized guidelines for distal femur IO placement.

ARTICLE HISTORY

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Introduction

Establishment of vascular access is a fundamental component of trauma care and volume resuscitation. According to the advanced trauma life support and tactical combat casualty care guidelines, intraosseous (IO) access should be promptly initiated when rapid peripheral intravenous access cannot be achieved (1,2). The IO route offers a non-collapsible access point with a high first-attempt success rate and the capacity to deliver a wide range of fluids and medications- including crystalloids, colloids, blood products, and pharmacologic agents- at effective flow rates, making it a compelling first-line option for prehospital patients in extremis (3). The food and drug administration (FDA) has approved IO access at the proximal humerus, proximal tibia, and sternum for the administration of fluids and medications in adult patients. Several reports published in recent years indicate that emergency medical service clinicians have been increasingly favoring IO access *via* the distal femur during out-of-hospital

cardiopulmonary resuscitation. The distal femur site offers high success rates, minimizes interference with the already crowded head and chest areas during resuscitation, potentially reducing the risk of dislodgment, and provides high flow rates (4–6). However, the feasibility of this method of IO access has not been assessed in trauma patients, who may differ substantially from those with out-of-hospital cardiac arrest.

The distance between the skin surface and the cortical bone is a critical anatomical factor in achieving successful IO access. In the current study, we aimed to evaluate the soft tissue depth- the distance between the skin and the bone cortex- at the distal femur using ultrasound (US), both without pressure and with gentle pressure applied to the soft tissue at the insertion site.

Methods

This prospective case series study was conducted at Rambam health care campus in Haifa, Israel. One

hundred healthy medical student volunteers were enrolled. Inclusion criteria were: healthy individuals aged 18 to 50 years, with no known pathology involving the knee joint, no history of knee surgery within the past year, and intact skin over the anterior knee. The study was approved by the institutional review board of Rambam health care campus Haifa, Israel (approval number 0167-23-RMB). Written informed consent was obtained from all participants prior to enrollment.

All participants underwent US evaluation of the distal femur to measure the distance from the skin surface to the bone. A 3-12MHz linear US transducer (VScan Air, GE Health care, USA) was used for this study. A transverse cross section of the soft tissue was visualized and US calipers were used to measure the sonographic depth from skin to bone.

Three physicians with prior experience in musculoskeletal point-of-care US performed the assessments. Each measurement was repeated by two physicians, and in cases of discrepancy, the average value was recorded. Participants were positioned supine with the leg extended in a neutral, horizontal orientation. A standardized template was used to mark the measurement site, located 2 cm proximal to the superior border of the patella. Two measurements were obtained for each participant: one at baseline with the transducer placed lightly on the skin without pressure, and a second with gentle downward pressure applied to the transducer. The measurement site (left or right) was selected arbitrarily. Demographic data- including age, sex, weight, height, and body mass index (BMI)- were also collected.

To ensure reliable entry into the medullary cavity, IO needles must exceed the soft tissue depth by at least 5 mm. Accordingly, when using the longest standard IO needle (45 mm), the soft tissue depth should not exceed 40 mm (7). Therefore, participants with a skin-to-bone depth greater than 40 mm were considered at high risk of insertion failure.

Statistical Analysis

All students who consented to participate were included. Categorical data were presented as counts and

percentages. Continuous variables were reported as medians and interquartile ranges (IQR). The associations between soft tissue depth and both age and BMI were assessed using Spearman's rank correlation coefficient (ρ) due to non-normal distribution of the variables as determined by Shapiro-Wilk test. A two-tailed p -value <0.05 was considered statistically significant. Statistical analyses were performed using Python (version 3.9) with `scipy.stats`, `numpy`, and `pandas` libraries.

Results

One hundred volunteers were included in the analysis. The median age of the study cohort was 27.3 years (IQR 25.0–29.0), and 64 participants (64.0%) were male. The BMI values in the cohort ranged from 17.42 kg/m² to 35.26 kg/m², with a median of 22.86 kg/m² (IQR 20.81–25.03). Only one subject (1.0%) had a BMI ≥ 30 kg/m². The distributions of age and BMI among study participants are illustrated in Figure 1.

The median soft tissue depth across participants was 25.0 mm (IQR 21.9–29.6) without pressure, and 14.0 mm (IQR 12.0–16.0) when gentle pressure was applied with the US transducer. None of the volunteers had a soft tissue depth exceeding 40 mm. Median soft tissue depth and corresponding 95% confidence intervals are presented in Figure 2.

Both age and BMI demonstrated a moderate, statistically significant correlation with soft tissue depth (Spearman's $\rho = 0.31$, $p=0.002$ for age and $\rho = 0.34$, $p=0.001$ for BMI). The analysis revealed no significant differences between sexes when the measurement was performed without pressure application (25.0 mm [IQR 20.9–28.4] vs. 25.0 mm [IQR 20.9–29.3], $p=0.75$) and with gentle pressure was applied (13.8 mm [IQR 12.0–16.0] vs. 14.0 mm [IQR 11.9–16.0], $p=0.99$).

Discussion

In this prospective US-based study of young, healthy, non-obese adult volunteers, the median soft tissue depth at

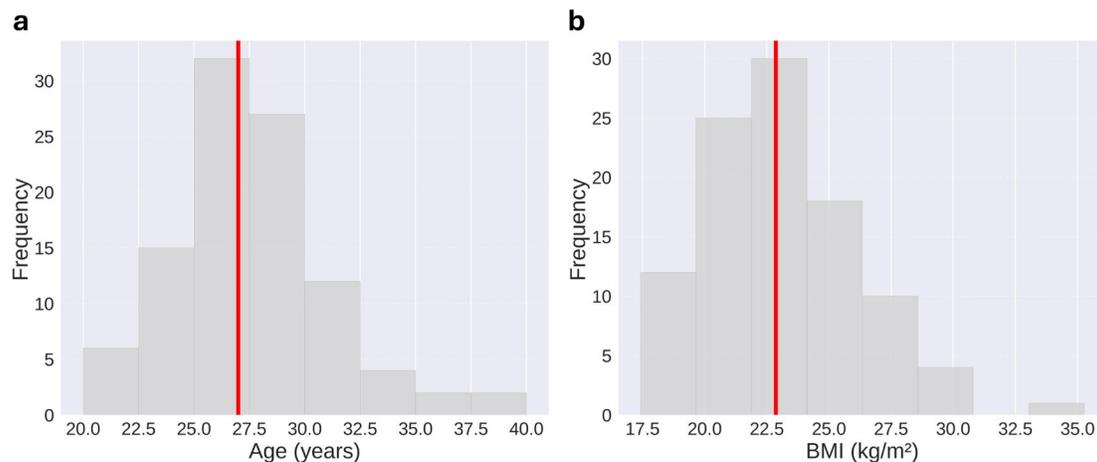


Figure 1. Distributions of age (a) and BMI (b) among 100 study participants.

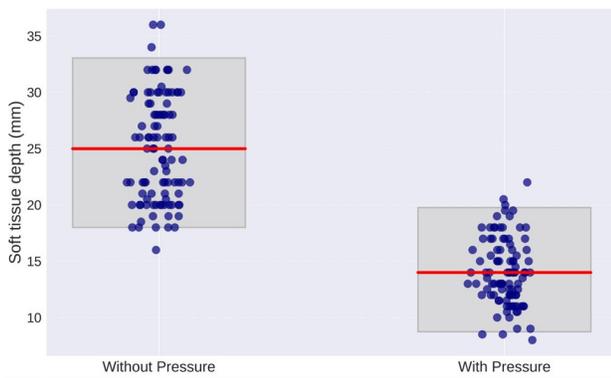


Figure 2. Median soft tissue depth and corresponding 95% confidence intervals.

the distal femur insertion site was 25.0 mm (IQR 21.9–29.6) without pressure and 14.0 mm (IQR 12.0–16.0) with gentle US probe compression. These values are well within the safe insertion range for most commercially available IO devices. None of the participants had a soft tissue depth exceeding 40 mm.

Traditionally, IO access in adults is performed at the proximal humerus, proximal tibia, or sternum. However, recent reports indicate a shift among emergency medical service clinicians toward using the distal femur for IO access during out-of-hospital cardiopulmonary resuscitation. Rayas et al. evaluated distal femur IO access in adults undergoing out-of-hospital cardiac arrest and reported high success rates with comparable clinical outcomes (6). This site offers advantages, including avoidance of the already crowded head and chest areas during initial prehospital care, potentially lower dislodgment rates (particularly among agitated trauma patients), and high flow rates. Lairet et al. reported that crystalloid infusion through an IO needle in the distal femur of an adult 71 kg swine, using a high-pressure system, achieved a flow rate of 138 mL/min. In the same model, a mean infusion rate of 213 mL/min was achieved in the proximal humerus and 103 mL/min in the proximal tibia. The difference between the femoral and humeral insertion sites did not reach the threshold for statistical significance (5). In an older study published in 1993, Warren et al. found, using a piglet model weighing 12–23 kg, that under gravity the average flow rate at the tibial site was 59% lower than at the femoral site. Under 300 mmHg pressure, the researchers reported an infusion rate of 29.5 mL/min in the femur, compared with only 17.0 mL/min in the tibia. Hypovolemia caused a further decrease in flow rates, averaging 32% (4). In canine cadavers, both gravity and pressurized infusion rates at the femoral IO site were comparable to those achieved in the humerus and significantly higher than rates observed through the tibia. The pressurized infusion rate at the femur was 2.1 mL/kg/min (8).

Despite its potential, distal femur IO access may be limited in adult trauma patients with greater skeletal muscle mass, in contrast to the typically older and sarcopenic population seen in cardiac arrest cases. Additionally, Rayas et al. noted that paramedics were permitted to perform a vertical “cut-down” incision over the insertion site to facilitate IO placement. However, the frequency of this intervention was

not reported. This technique could increase procedure time, patient discomfort, and the risk of complications such as infection.

The currently commercially available IO devices include manually inserted devices, mechanical, spring-loaded devices, and drill-assisted devices. Several studies have compared drill-assisted and spring-loaded devices, with mixed findings regarding their efficacy (9–11). We found no reports of successful use of mechanical IO devices at the distal femur site in adult patients. However, according to the manufacturers, spring-loaded devices require firm pressure on the insertion site, which compresses the overlying soft tissue and reduces the effective distance to the bone, in contrast to drill-assisted IO devices, which do not rely on external compression; the needle is advanced until bone contact is achieved. A 5 mm black mark on the needle must remain visible above the skin before insertion. In our study, such compression reduced the soft tissue depth at the distal femur by more than 10 mm, potentially enabling the use of spring-loaded IO devices in patients with soft tissue depth exceeding 40 mm.

Distal femur IO access is an FDA-approved and clinically acceptable option for pediatric patients (12). Although it is rarely used in practice, as reported by some studies (13,14), a recent study from Florida found that prehospital IO access at the distal femur had similar success and complication rates compared to the more commonly used proximal tibia (15).

Our previous study demonstrated that over 20% of trauma casualties had soft tissue depth exceeded the length of the standard IO needle (45 mm) (16). In that study we measured the distance from the skin to the cortex of the distal femur using a single sagittal computed tomography image obtained during routine trauma evaluation. Measurements were taken at a fixed distance from the superior patellar border without correcting for axis deviation, potentially introducing variability of 2–3 mm. Furthermore, maintaining firm probe contact with minimal pressure is essential during US evaluation, as even slight pressure can reduce the skin-to-cortex distance by several millimetres—more accurately simulating the real-world conditions of IO needle placement using drill-assisted devices. These factors may suggest that the current analysis more accurately reflects actual soft tissue depth and the needle length required for IO access at the distal femur. However, our previous analysis included real-world patients with a broader range of age and BMI. The prevalence of obesity among severe trauma casualties varies worldwide, with rates of up to 21% reported in the USA and up to 8.3% in Europe (17,18). It is expected to be even lower in military populations due to fitness requirements and selection processes.

Limitations

This study has several limitations. First, although our cohort consisted of young and predominantly male volunteers representing the trauma casualty population, the homogeneity of the study group—healthy, non-obese participants—may limit the generalizability of our findings.

Since we observed a moderate correlation between BMI and soft tissue depth, it is plausible that patients with higher BMI- and possibly higher muscle mass, such as soldiers- would have increased soft tissue depth at the femoral site. Additionally, IO access is used not only in trauma and cardiac arrest patients. The characteristics of these populations may differ from those of our cohort. Second, we focused solely on the anatomical feasibility of distal femur IO access. Other factors, such as errors in identifying the insertion site or incorrect needle angle, may increase failure rates. Third, all measurements were performed by investigators aware of the study's cutoff threshold, which may have introduced observer bias. Fourth, all measurements were performed in the axial plane, and soft tissue depth may have been overestimated if the probe was not precisely aligned at a 90-degree angle to the femur.

Conclusions

In conclusion, our study demonstrates that the soft tissue depth at the distal femur in young, healthy, non-obese adults is generally within the range suitable for most IO access devices, especially when gentle pressure is applied using spring-loaded devices. These findings support the anatomical feasibility of distal femur IO access in trauma settings. However, variations in body composition, particularly in trauma patients with higher BMI or muscle mass, must be considered. Further research is needed to evaluate clinical success rates and procedural challenges in real-world trauma populations.

Authorship Statement

Conception and design of the work: Omri Simchon, Ofir Lavi, Shaked Ankol, Danny Epstein; Data collection: Omri Simchon, Ofir Lavi, Shaked Ankol. Supervision: Nadeem Shorbaji, Danny Epstein; Analysis and interpretation of the data: Omri Simchon, Ofir Lavi, Shaked Ankol, Nadeem Shorbaji, Danny Epstein; Statistical analysis: Danny Epstein; Drafting the manuscript: Omri Simchon, Ofir Lavi, Shaked Ankol, Nadeem Shorbaji; Critical revision of the manuscript: Omri Simchon, Ofir Lavi, Shaked Ankol, Nadeem Shorbaji, Danny Epstein; Approval of the final manuscript: Omri Simchon, Ofir Lavi, Shaked Ankol, Nadeem Shorbaji, Danny Epstein

Declaration of Generative AI in Scientific Writing

The authors did not use a generative artificial intelligence (AI) tool or service to assist with preparation or editing of this work. The authors take full responsibility for the content of this publication.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

References

1. American College of Surgeons. Advanced trauma life support for doctors. 10th ed. Chicago, IL: American College of Surgeons; 2018.
2. Anonymous A. Tactical Combat Casualty Care (TCCC) guidelines for medical personnel 15 December 2021. *J Spec Oper Med.* 2022;22(1):11–7. Cited in: PMID: 35278312. doi:10.55460/ETZI-SI9T.
3. Tyler JA, Perkins Z, DeAth HD. Intraosseous access in the resuscitation of trauma patients: a literature review. *Eur J Trauma Emerg Surg.* 2021;47(1):47–55. Cited in: PMID: 32078703. doi:10.1007/S00068-020-01327-Y.
4. Warren DW, Kissoon N, Sommerauer JF, Rieder MJ. Comparison of fluid infusion rates among peripheral intravenous and humerus, femur, malleolus, and tibial intraosseous sites in normovolemic and hypovolemic piglets. *Ann Emerg Med.* 1993;22(2):183–6. doi:10.1016/s0196-0644(05)80199-4. Cited in: PMID: 8427428.
5. Lairet J, Beberta V, Lairet K, Kacprowicz R, Lawler C, Pitotti R, Bush A, King J. A comparison of proximal tibia, distal femur, and proximal humerus infusion rates using the EZ-IO intraosseous device on the adult swine (*Sus scrofa*) model. *Prehosp Emerg Care.* 2013;17(2):280–4. Cited in: PMID: 23331182. doi:10.3109/0903127.2012.755582.
6. Rayas EG, Winckler C, Bolleter S, Stringfellow M, Miramontes D, Shumaker J, Lewis A, Wampler D. Distal femur versus humeral or tibial IO, access in adult out of hospital cardiac resuscitation. *Resuscitation.* 2022;170:11–6. Cited in: PMID: 34748766. doi:10.1016/J.RESUSCITATION.2021.10.041.
7. Kehrl T, Becker BA, Simmons DE, Broderick EK, Jones RA. Intraosseous access in the obese patient: assessing the need for extended needle length. *Am J Emerg Med.* 2016;34(9):1831–4. Cited in: PMID: 27344097. doi:10.1016/J.AJEM.2016.06.055.
8. Lange J, Boysen SR, Bentley A, Atilla A. Intraosseous catheter flow rates and ease of placement at various sites in canine cadavers. *Front Vet Sci.* 2019;6:312. Cited in: PMID: 31608294. doi:10.3389/fvets.2019.00312.
9. Shina A, Baruch EN, Shlaifer A, Shovali A, Levi M, Yosefy O, Segal D, Bader T, Shavit I, Yitzhak A. Comparison of two intraosseous devices: the NIO versus the EZ-IO by novice users-A randomized cross over trial. *Prehosp Emerg Care.* 2017;21(3):315–21. Cited in: PMID: 70553. doi:10.1080/10903127.2016.1247201.
10. Kay VC, Gehrz JA, Grady DW, Emerling AD, McGowan A, Reilly ER, Beberta VS, Nassiri J, Vinals J, Schrader A, et al. Application times, placement accuracy, and user ratings of commercially available manual and battery-powered intraosseous catheters in a high bone density cadaveric swine model. *Mil Med.* 2024;189(9–10):1960–7. doi:10.1093/milmed/usad407.
11. Leidel BA, Kirchhoff C, Braunstein V, Bogner V, Biberthaler P, Kanz K-G. Comparison of two intraosseous access devices in adult patients under resuscitation in the emergency department: a prospective, randomized study. *Resuscitation.* 2010;81(8):994–9. doi:10.1016/j.resuscitation.2010.03.038.
12. Morrison C, Disma N. Intraosseous access in children. New applications of an ancient technique. *Trends Anaesth Crit Care.* 2018;21:21–6. doi:10.1016/j.tacc.2018.04.004.
13. Ting A, Smith K, Wilson CL, Babl FE, Hopper SM. Pre-hospital intraosseous use in children: indications and success rate. *Emerg Med Australas.* 2022;34(1):120–1. doi:10.1111/1742-6723.13886; JOURNAL:JOURNAL:14422026;CTYPE:STRING:JOURNAL. Cited in: PMID: 34704359.
14. Pfeiffer D, Olivieri M, Brenner S, Gomes D, Lieftüchter V, Hoffmann F. Factors influencing the success and complications of intraosseous access in pediatric patients—a prospective nationwide surveillance study in Germany. *Front Pediatr.* 2023;11:1294322. doi:10.3389/FPED.2023.1294322/BIBTEX.
15. Zitek T, Antevy P, Garay S, Thorn M, Buckley E, Coyle C, Schepke KA, Farcy DA. Evaluating the success rate of distal

- femur intraosseous access attempts in pediatric patients in the prehospital setting: a retrospective analysis. *Prehosp Emerg Care*. 2025;29(6):776–781. doi:10.1080/10903127.2024.2398185. Cited in: PMID: 39230342.
16. Ankol S, Shorbaji N, Abramov R, Bahouth H, Raz A, Epstein D. Distal femur intraosseous access in adult trauma patients: a feasible option? *Am J Emerg Med*. 2023;65:192–4. doi:10.1016/j.ajem.2022.11.014.
 17. Nelson J, Billeter AT, Seifert B, Neuhaus V, Trentz O, Hofer CK, Turina M. Obese trauma patients are at increased risk of early hypovolemic shock: a retrospective cohort analysis of 1,084 severely injured patients. *Crit Care*. 2012;16(3):R77. Cited in: PMID: 22568946. doi:10.1186/cc11334.
 18. Fakhry SM, Morse JL, Garland JM, Wilson NY, Shen Y, Wyse RJ, Watts DD. Increasing BMI is associated with higher mortality, worsening outcomes and highly specific injury patterns following trauma: a multi-institutional analysis of 191,274 patients. *J Trauma Acute Care Surg*. 2021;90(2):376–83. Cited in: PMID: 33502149. doi:10.1097/TA.0000000000003040.