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INTERVENTIONAL RADIOLOGY

ORIGINAL ARTICLE

Comparison of the novel simultaneous biplane versus in-plane imaging technique in ultrasound-guided biopsy: a prospective randomized multi-operator cross-over phantom study

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PURPOSE

To evaluate and compare the in-plane and novel biplane imaging techniques in ultrasound-guided biopsies (USBx). USBx are effective for obtaining tissue samples in suspected malignancy or infection. The in-plane technique is the gold standard, offering continuous needle visualization. The biplane technique enables simultaneous in-plane and out-of-plane visualization, potentially improving biopsy outcomes. A study was conducted using gel phantoms to simulate USBx, with the goal of determining whether one technique offers distinct advantages over the other.

METHODS

A total of 30 participants (mean age: 30 ± 7 years; 20 men) were recruited, primarily consisting of physicians in training with varying levels of experience. Each participant performed biopsies on gel phantoms using both the in-plane and biplane techniques in a randomized order after watching a standardized tutorial video. Procedure-related parameters were analyzed, and post-intervention questionnaires, including the NASA task load index (NASA-TLX), were collected to assess cognitive workload and personal preferences.

RESULTS

All participants achieved successful biopsies with both techniques. The first-puncture success rate was significantly higher with the biplane technique (83% vs. 63%; $P = 0.01$). The biplane technique required significantly fewer biopsy attempts than the in-plane approach (37 vs. 43; $P = 0.03$). Although the biplane technique had a longer "mean time to first successful biopsy" (120 seconds vs. 72 seconds), this difference was not statistically significant ($P = 0.09$), likely due to high variability. No significant differences were found in safety-related parameters, including the number of skin punctures, needle retractions, percentage of time the needle tip was visible, and the number of biopsy attempts without needle tip visualization. The NASA-TLX indicated higher mental demand with the biplane technique ($P = 0.013$), but other dimensions showed no significant differences. Overall, 83% of participants, including 88% of more experienced operators, preferred the biplane technique, citing enhanced visualization and perceived safety.

CONCLUSION

In this study, the biplane technique in USBx was substantially superior in terms of total biopsy attempts and first-puncture success rate compared with the in-plane approach. It may offer safety and efficiency advantages, particularly for less-experienced operators. Further studies with larger sample sizes and experienced operators, especially in clinical settings, are needed to determine clear superiority.

CLINICAL SIGNIFICANCE

These findings suggest that biplane imaging may be especially beneficial for training less-experienced operators and in cases with elevated complication risk.

KEYWORDS

Biplane imaging, handheld ultrasound device, in-plane vs biplane, phantom study, ultrasound, ultrasound guided biopsy

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Ultrasound is an easily available and safe imaging modality, offering a wide range of applications in daily clinical practice. While depicting the anatomical structures of the examined area for diagnostic purposes, it can also provide reliable guidance in procedures such as vascular punctures or biopsies.[1-4]

Ultrasound-guided biopsy (USBx) allows for minimally invasive diagnosis with high success rates and a favorable safety profile. It can be used to diagnose thoracic, abdominal, neck, and musculoskeletal pathologies.[2-5] In cases of malignancy, molecular profiling can also be easily achieved, supporting the modern era of targeted therapy.[4,6,7] The diagnostic yields for tissue identification and molecular profiling are comparable to those reported for computed tomography-guided biopsy methods.[7] In addition to its high success rate and safety, USBx offers several other advantages: it does not require sedation, involves no radiation exposure for patients and staff, can be safely performed in patients with poor performance status, and presents economic benefits over other diagnostic procedures.[7-10]

In standard ultrasound devices, depending on the specific case and preferred approach, the operator can choose between the in-plane and out-of-plane techniques. In the context of vascular access, the in-plane approach aligns with the long axis of the vessel, while the out-of-plane approach corresponds to the short axis. The probe is parallel to the needle in the in-plane technique and perpendicular to it in the out-of-plane technique.[11] Despite its widespread use, the in-plane approach requires precise alignment, which can be challenging in anatomically complex regions or for less-experienced operators.

Main points

- While the in-plane approach remains the gold standard in ultrasound-guided biopsies (USBx), the novel biplane technique—which provides simultaneous in-plane and out-of-plane views in real time—was substantially superior in terms of total attempts and first-time success rate, potentially offering safety and efficiency advantages.
- According to the post-intervention questionnaire, the majority of participants expressed a preference for the biplane technique over the in-plane approach.
- Based on these results, biplane imaging appears to be the method of choice not only for less-experienced operators but also for USBx procedures with a higher expected risk of complications.

A novel option is biplane imaging, which allows for simultaneous visualization of both axes in real-time, combining the advantages of both imaging techniques without the need to rotate the probe. By simultaneously displaying the needle trajectory and the lesion with its surrounding structures, the biplane approach appears to offer clear advantages over other well-established imaging techniques. The ability to visualize both in-plane and out-of-plane views at once may reduce complications, improve accuracy, and enhance operator confidence.

Although previous studies have explored biplane imaging for vascular catheterization and other specific interventions, its utility in USBx remains underexplored.[12,13] Research into vascular access suggests that the multiplane—or biplane—approach may be a safer and more reliable technique, particularly for less-experienced operators.

This study compares the biplane and in-plane techniques in simulated USBx performed on phantoms, evaluating differences and potential superiority between the two techniques.

Methods

This randomized, multi-operator, crossover study was conducted in the Department of Pulmonology at the [Klinik Ottakring, Vienna]. Operators from different departments with varying levels of experience in ultrasound-guided diagnostics and interventions were included in the study: medical students, trainee doctors, physicians, radiologists, and specialists. Each participant went through four steps.

Pre-intervention phase (steps 1 and 2)

First, participants completed a pre-intervention questionnaire regarding their basic characteristics and level of experience. Operators with prior experience using the Butterfly ultrasound device or the biplane technique were excluded to ensure unbiased skill evaluation.

In step 2, participants were asked to watch a standardized 10-minute educational tutorial video. The video introduced the objectives of the study, presented relevant background information, and lastly, explained the key steps for performing successful USBx using either technique. The video could be watched more than once, and there was no time limit for this phase. Afterward, participants were allowed to ask questions; however, study assistants were only permitted to answer questions addressed in the tutorial video.

Intervention phase (step 3)

In this phase, the actual procedures were performed. It consisted of two intervention sessions, in which the operator had to successfully perform a biopsy using one of the two techniques—biplane or in-plane—at a time. Both interventions were performed in succession. To minimize learning effects, the sequence of techniques was randomized for each participant using an online randomization tool.

Each intervention phase ended when the operator successfully obtained a biopsy using the assigned technique. After completing the first intervention, the operator performed the procedure using the other technique. The entire intervention phase was recorded on camera, allowing for precise analysis and measurement of the relevant parameters using a video editor.

Post-intervention phase (step 4)

After both interventions, participants were asked to complete a post-intervention questionnaire, including the modified NASA task load index (NASA-TLX) protocol[14], to assess personal preferences and experiences. Using the NASA-TLX, the workload for both intervention phases was quantified on a scale from 0 (low) to 20 (high) across six categories: mental, physical, and temporal demand, performance, effort, and level of frustration.

Ultrasound device, biopsy needle system and phantom

The novel Butterfly iQ3 (Butterfly Network, Inc., Burlington, MA, USA) device with its standard probe was used for both imaging techniques: in-plane and biplane. In biplane mode, the needle is visible in-plane on one half of the screen, while the altitude can be adjusted simultaneously in the perpendicular (out-of-plane) view on the other half of the screen (Figures 1 and 2). The biopsy itself was performed using a semi-automatic firing core biopsy needle (BARD Mission®, Disposable Core Biopsy Instrument, 18 G × 10 cm, adjustable throw of 10 or 20 mm). All participants were instructed to use a 20 mm throw.

The phantom models used in this study were self-made, composed of gelatine, and constructed similarly to those used in several other studies.[15-17] The gelatine solution was standardized across batches to ensure

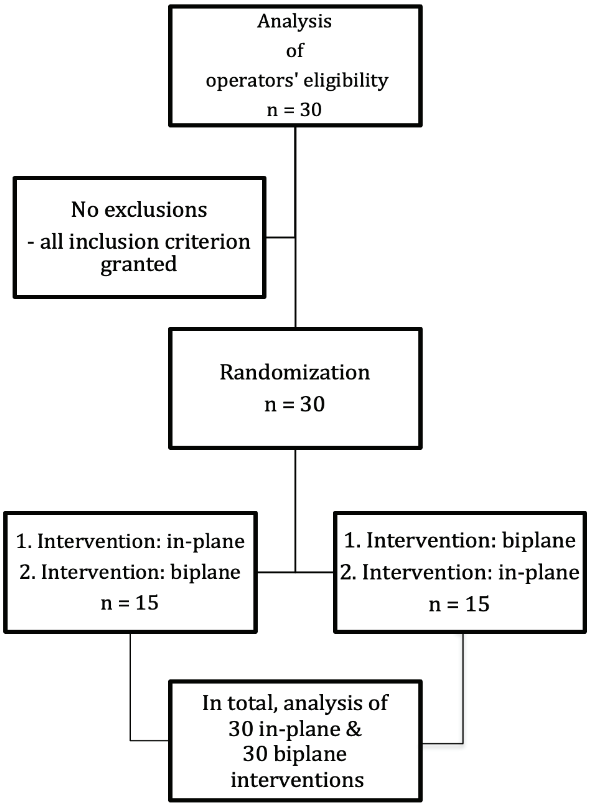

Figure 1. Operator recruitment and randomization.

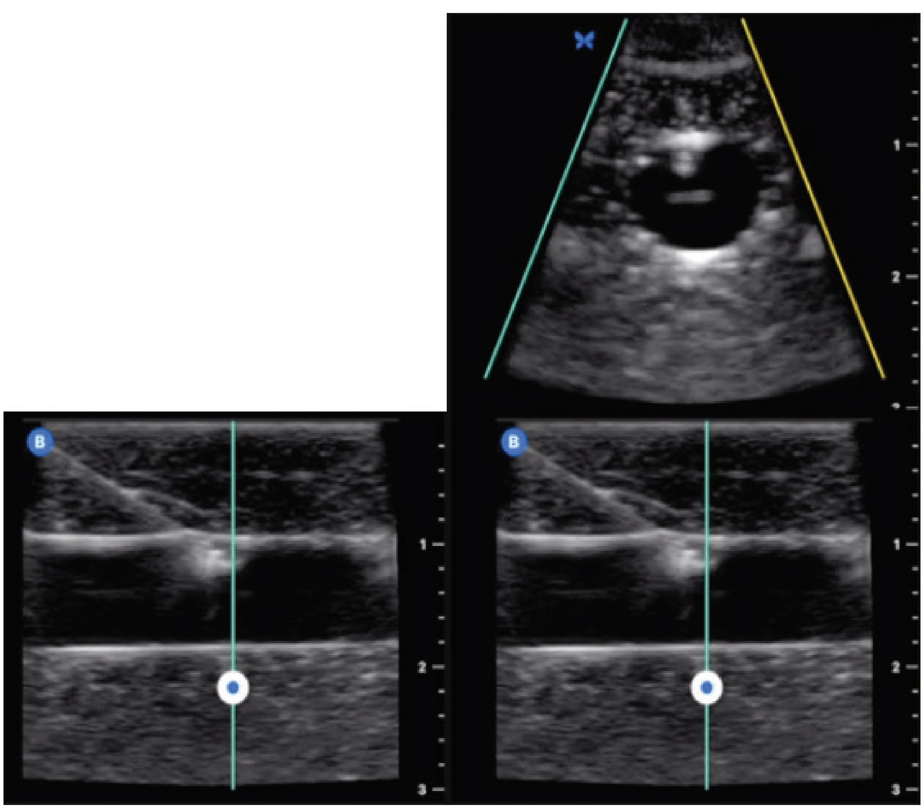

Figure 2. Both techniques illustrated. Left: in-plane mode. Right: biplane mode. The probe and needle are simultaneously displayed in both axes in real time.

uniform consistency, and lesions were uniformly embedded at a depth of 5 cm. The lesions within the phantom were made from Play-Doh, a modeling compound for children (Figure 2). The diameter of each lesion was approximately 1 cm. Soluble food coloring was added to the gelatine solution to prevent target visualization without ultrasound (Figures 2 and 3).

The transducer of the Butterfly iQ3 ultrasound device enables the combination of phased, curved, and linear arrays within a single probe, using Ultrasound-on-Chip™ technology to acquire images at a frequency range of 1–12 MHz. Unlike traditional ultrasound devices that rely on piezoelectric crystals, Ultrasound-on-Chip™ integrates thousands of transducer elements directly onto a semiconductor-based micro-electro-mechanical systems array, replacing bulky piezoelectric transducers with a more compact, software-driven solution.

Outcome variables

During the intervention phase, several parameters were measured and assessed to compare both techniques. The primary outcomes were: "time to first successful biopsy," defined as the time from when the probe was first placed on the phantom until the biopsy needle was triggered and a sample successfully obtained; "number of biopsy attempts"; and "first puncture success rate."

To evaluate the safety profile and potential complications, several surrogate parameters were also considered: "percentage of time with needle tip visualization," "number of biopsy attempts," "number of skin punctures," "number of biopsy attempts without needle tip visualization," and "number of times the cutting biopsy needle was retracted within each attempt."

The post-intervention questionnaire was used to assess the preferred technique for USBx and to evaluate workload differences across all six NASA-TLX categories: mental, physical, and temporal demand; performance; effort; and frustration.

Statistical analysis

All statistical analyses were performed using Stata (version 17.0). Data processing and analysis scripts (.do files), along with the dataset, are available at the GitHub repository: https://github.com/kushiel42/butterfly_paper

Figure 3. Intervention setting. The tablet screen displays the biplane mode. The top half of the screen shows the short-axis (out-of-plane) view, while the bottom half depicts the long-axis view. The operator uses the biplane mode to perform an ultrasound-guided biopsy in the presented gel phantom.

Descriptive statistics were used to summarize participant characteristics and procedural parameters. Categorical variables were presented as counts and percentages, as shown in Tables 1 and 2. Continuous variables were reported as medians with interquartile ranges (IQRs) or means with standard deviations (SDs), depending on data distribution assessed via visual inspection.

The primary exposure variable was the biopsy technique used—either in-plane or biplane. Outcome variables included time to first successful biopsy, total number of biopsy attempts, first puncture success rate, and NASA-TLX scores.

Given the paired nature of the data and the sample size, non-parametric statistical tests were applied. The Wilcoxon signed-rank test was used to compare paired continuous or ordinal variables between the two techniques. This test was appropriate due to the small sample size and the ordinal or non-normally distributed nature of several variables. Variables analyzed with the Wilcoxon signed-rank test included time to first successful biopsy, the total number of biopsy attempts, percentage of time the needle tip was visible, percentage of time the needle was partially visible, number of skin punctures, number of needle retractions and number of biopsy attempts without needle tip visualization.

McNemar's test was used to compare paired categorical data—specifically, first puncture success rates between the in-plane and biplane techniques. This test is suitable for analyzing dichotomous outcomes in paired samples.

Mixed-effects linear regression models were employed to account for repeated measurements and intra-participant variability in NASA-TLX scores. Each NASA-TLX dimension (mental demand, physical demand, temporal demand, performance, effort, and frustration) was modeled separately, with the biopsy technique as a fixed effect and participant ID as a random effect. No additional covariates were included, as the randomized crossover design inherently controlled for potential confounders. A two-tailed P value < 0.05 was considered statistically significant for all analyses. Effect sizes and 95% confidence intervals (CIs) were reported where applicable to enhance result interpretation.

Ethics approval

The institutional review board waived the need for formal approval. Informed consent was obtained from all participants.

Results

A total of 30 participants (Table 1) were included in the study, with a mean age of 30.3 years (± 7 years). The cohort comprised 20 men (67%) and 10 women (33%). The majority were trainees, including medical students and junior doctors, each group representing 20% of the participants. Only 13% (n = 4) were specialists; 80% (n = 24) of participants had advanced training in ultrasound diagnostics.

Analysis of procedural metrics (Table 2) revealed no significant differences between the in-plane and biplane techniques across several parameters. Although the time to first successful biopsy was longer with the biplane technique (120 seconds vs. 72 seconds, P = 0.096), this difference was not statistically significant, likely due to variability among participants. The percentage of time the needle tip was visible was similar between the two techniques (59% for in-plane vs. 61% for biplane; P = 0.909). Likewise, the percentage of time the needle was partially visible showed no significant difference (P = 0.885). Safety-related measures, including the number of skin punctures (P = 0.833), needle retractions (P = 0.563), and biopsy attempts without needle tip visualization (P = 0.433), were also comparable. These findings suggest that both techniques demonstrate similar profiles in terms of procedural and safety parameters.

The median time to first successful biopsy was comparable between the in-plane (69.5 seconds; IQR: 44–109 seconds) and biplane techniques (73.5 seconds; IQR: 50–128 seconds). Mean times were 84.07 seconds (SD: 50.62) for in-plane and 107.8 seconds (SD: 86.69) for biplane. Although the biplane technique exhibited a higher mean time, the difference was not statistically significant (P = 0.096; Wilcoxon signed-rank test), likely due to substantial variability in the data. The Bland–Altman plot (Figure 4) highlights this variability, showing considerable overlap in times between the two techniques.

Efficacy of biopsy techniques

Despite the absence of significant differences in the previously mentioned parameters, the biplane technique demonstrated superior efficacy in key outcome measures (Figure 5). The total number of biopsy attempts required was significantly lower with the biplane technique compared with the in-plane technique. Participants required fewer attempts to achieve a successful biopsy using the biplane method, indicating greater procedural efficiency (P = 0.030).

Moreover, the biplane technique achieved a significantly higher first puncture success rate (83%) compared with the in-plane technique (63%, P = 0.01). McNemar's test confirmed the statistical significance of this difference (P = 0.01), supporting the rejection of the null hypothesis that there is no difference in first puncture success rates between the techniques. These results highlight the enhanced efficacy of the biplane technique in achieving successful biopsies on the initial attempt (Figure 6).

Although the biplane technique proved more effective, it was associated with increased mental workload for practitioners.

Table 1. Baseline characteristics of all participants

Characteristics	Number of participants (n = 30)
Age	30.3 ± 7
Sex	
Men	20 (67%)
Women	10 (33%)
Field of practice	
Medical student	7 (23.3%)
Junior doctors	6 (20%)
Trainee doctors	13 (43.3%)
Specialists	4 (13.3%)
Field of expertise	
Students	7 (23.3%)
Physicians	6 (20%)
Radiologists	2 (6.7%)
Internal medicine (various specialties)	13 (43.3%)
Anesthesiologists	1 (3.3%)
Surgeons	1 (3.3%)
Advanced training in ultrasound diagnostics	24 (80%)
Number of diagnostic ultrasound examinations performed	
Never	2 (6.7%)
<25 times	7 (23.3%)
<50 times	5 (16.7%)
<100 times	5 (16.7%)
>100 times	11 (36.7%)
Subjectively estimated level of ultrasound diagnostic skills	
Not confident	9 (30%)
Little confident	10 (33.3%)
Confident	9 (30%)
Very confident	2 (6.7%)
Advanced training in USBx	4 (13.3%)
Number of USBx performed	
Never	17 (56.7%)
<25 times	9 (30%)
<50 times	3 (10%)
>50 times	1 (3.3%)
Subjectively estimated level of USBx	
Not confident	20 (66.7%)
Little confident	5 (16.7%)
Confident	5 (16.7%)
Very confident	0 (0 %)
Subjectively estimated level of ultrasound Overall ultrasound skill level (1 = high, 5 = low)	
1	2 (7%)
2	6 (20%)
3	6 (20%)
4	14 (47%)
5	2 (7%)

USBx, ultrasound-guided biopsy.

The NASA-TLX revealed that mental demand was significantly higher for the biplane technique than for the in-plane technique. Mean mental demand scores were 10.8 for the biplane and 9.1 for the in-plane. A mixed-effects linear regression model, accounting for repeated measures within participants, demonstrated that this difference was statistically significant (95% CI: 0.357–3.043, *P* = 0.013), indicating lower mental demand scores with the in-plane technique. The higher NASA-TLX mental demand scores for the biplane technique suggest a steeper learning curve, which may lessen with experience.

Discussion

The simultaneous display of both axes in real time may inherently suggest the superiority of the novel biplane approach over the gold standard in-plane technique in USBx. Although this study appears to be unique in investigating the role of biplane imaging in USBx, several studies have explored its application in other interventions. In ultrasound-guided regional anesthesia, biplane imaging has been reported to decrease procedure time and the number of attempts and needle passes, improve block success, and enhance safety by reducing the risk of unintended intraneural, intrapleural, or intravascular injection.[18] More commonly, studies examining the biplane technique in the context of vascular access have reported improved performance and feasibility, fewer puncture attempts and needle redirections, and a lower incidence of complications.[12,13,18-20] Similar findings have also been observed in other, more specific ultrasound-guided interventions.[21,22]

To confidently claim the superiority of one technique over the other, it is essential first to identify the factors that determine a technique's effectiveness. A technique is considered superior based on three key criteria: efficiency, safety, patient comfort and convenience, and the difficulty of execution. While all participants successfully conducted biopsies using both techniques, it is important to note that the biopsies were performed on phantoms with no pre-specified limit on attempts. Each operator was allowed to take their time until one biopsy was successfully secured in each intervention phase. Therefore, the total number of biopsy attempts stands out as a potential indicator of superiority. The biplane technique performed substantially better in this regard. This may also suggest a safer approach, as fewer biopsy attempts reduce the likelihood of complications. The first puncture success rate was also

Table 2. Procedural parameters and outcomes for in-plane and biplane techniques

Parameters	In-plane	Biplane	*P* value
Time to first successful biopsy	72 sec	120 sec	0.09
First puncture success rate	19/30 (63%)	25/30 (83%)	**0.01**
Percentage of time with needle tip (mean)	59%	61%	0.43
Number of biopsy attempts (in total)	43	37	**0.03**
Number of skin punctures	52	52	0.83
Number of biopsy attempts without needle tip visualization (in total)	13	10	0.89
Number of retractions of the cutting biopsy needle (total)	88	108	0.56
Preferred technique	5/30 (17%)	25/30 (83%)	
NASA-TLX (0 = low, 20 = high)			
Mental demand	9.1	10.8	**0.013**
Physical demand	4.0	4.2	>0.05
Temporal demand	5.7	5.9	>0.05
Performance	6.2	6.5	>0.05
Effort	6.6	7.2	>0.05
Frustration	5.6	5.6	>0.05

NASA-TLX, NASA task load index.

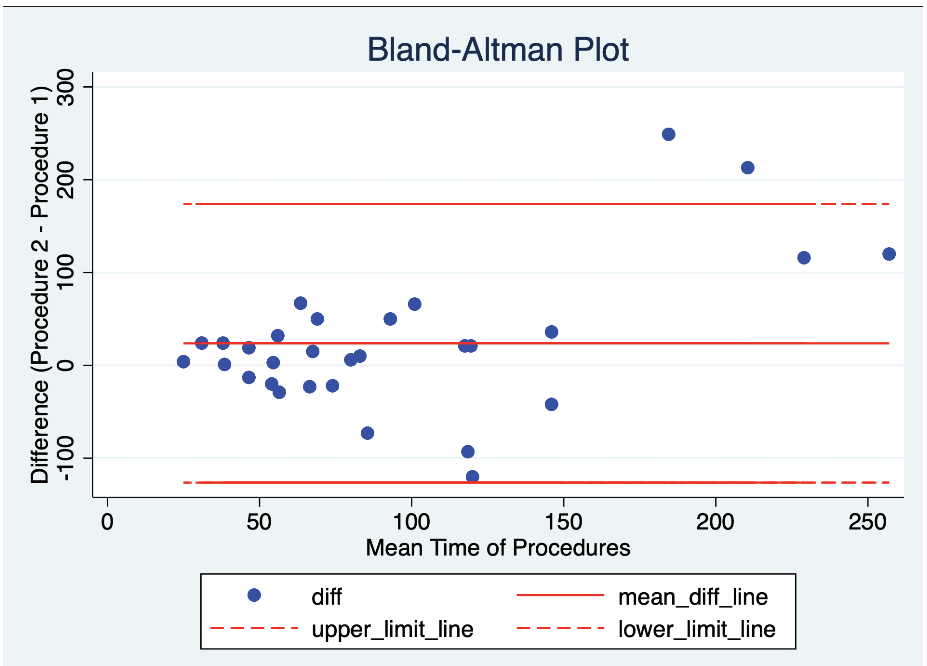

Figure 4. Bland-Altman plot of time differences between in-plane and biplane techniques.

statistically significant, indicating a higher safety profile, greater ease of execution, and improved patient comfort. This provides further support in favor of the biplane technique.

While there was no significant difference in the time to achieve the first successful biopsy individually, the mean total time notably favored the in-plane technique, possibly indicating greater efficiency and a less complex procedure overall. A faster method could be particularly relevant for unstable patients or those with poor performance status. However, as indicated by the post-intervention questionnaire, this result may be influenced by limited operator experience with the biplane technique. The additional out-of-plane axis in biplane mode introduces a mental challenge, requiring extra time for optimal needle placement and increasing procedural complexity compared with the in-plane approach. The post-intervention questionnaire further supports this, showing a statistically significant increase in mental demand for the biplane mode. These findings may, therefore, be misleading, as increased practice and familiarity with the biplane approach could yield different results.

In fact, another study comparing in-plane and biplane ultrasound-guided central venous catheterization found that participants who had considerably more training and were familiar with the biplane technique achieved shorter times to first successful catheterization using the biplane mode.[13] This suggests that the biplane mode does not, in fact, complicate USBx. Therefore, given the limitations of the study, the difference in "time to achieve the first successful biopsy" should be considered neither significant nor meaningful.

If taken into account, one could argue that a shorter time to first successful biopsy with the in-plane approach might imply a higher safety profile due to the reduced in situ duration of the biopsy needle. However, this, too, can be reasonably dismissed, as the additional axis view in the biplane mode arguably reduces the risk of complications—even with longer procedure times.

Based on the points made thus far, it can be concluded that the biplane mode not only seems to be superior in terms of safety but also appears to be at least as efficient as, if not more efficient than the in-plane mode—especially with more experience, considering the results of the other biplane study.[13] Interestingly, other surrogate parameters for patient safety, such as the percentage of time the needle tip is visualized or the number of retractions during biopsy, showed no significant differences. However, these results may vary in real-life settings.

The additional out-of-plane axis view, often cited as the main argument for a higher safety profile, can be disputed, as experienced operators are able to assess the perpendicular axis (out-of-plane) while remaining in-plane, using basic probe-tilting motions and adjusting the angle during the biopsy. Some of the more experienced participants cited this as the main reason why they saw no additional benefit in the biplane technique and, therefore, preferred the in-plane approach. However, there may be a status quo bias and a potential benefit even for highly experienced operators due to the continuous perpendicular axis view without requiring additional maneuvers—particularly in complicated biopsy cases. Nevertheless, this argument remains inconclusive in this study, as the number of very experienced operators was limited. It also remains unclear whether experienced radiologists with advanced manual skills would find the extra axis view distracting. However, it is likely that this factor would become increasingly irrelevant with more practice.

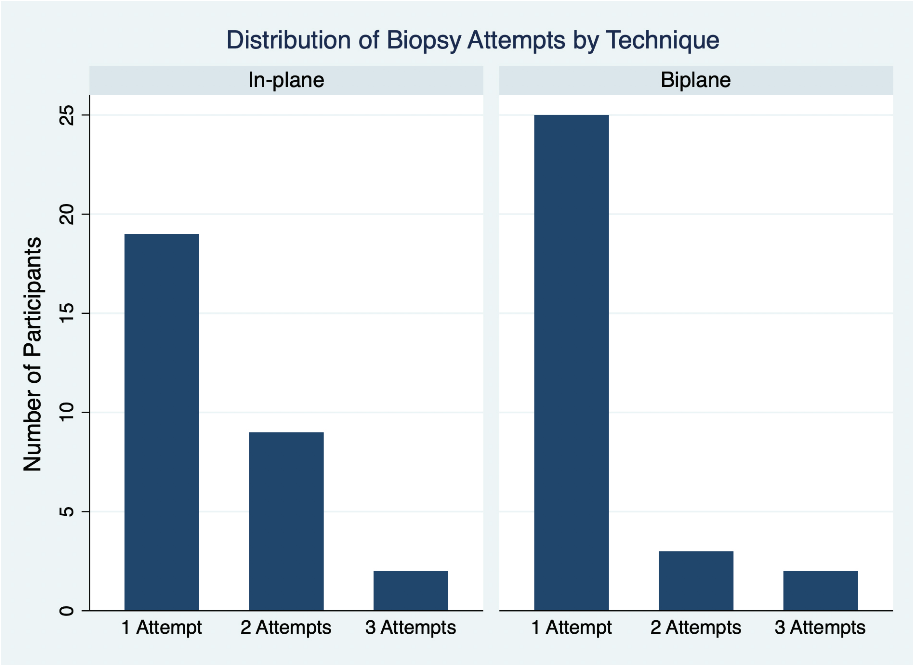

Figure 5. Distribution of biopsy attempts by technique. This figure shows the number of biopsy attempts required for both the in-plane and biplane techniques. The majority of participants in the biplane group (n = 21) required only one attempt, compared with the in-plane group, where 17 participants succeeded on the first attempt. A higher proportion of in-plane participants required two or more attempts, indicating greater variability in success rates with this method.

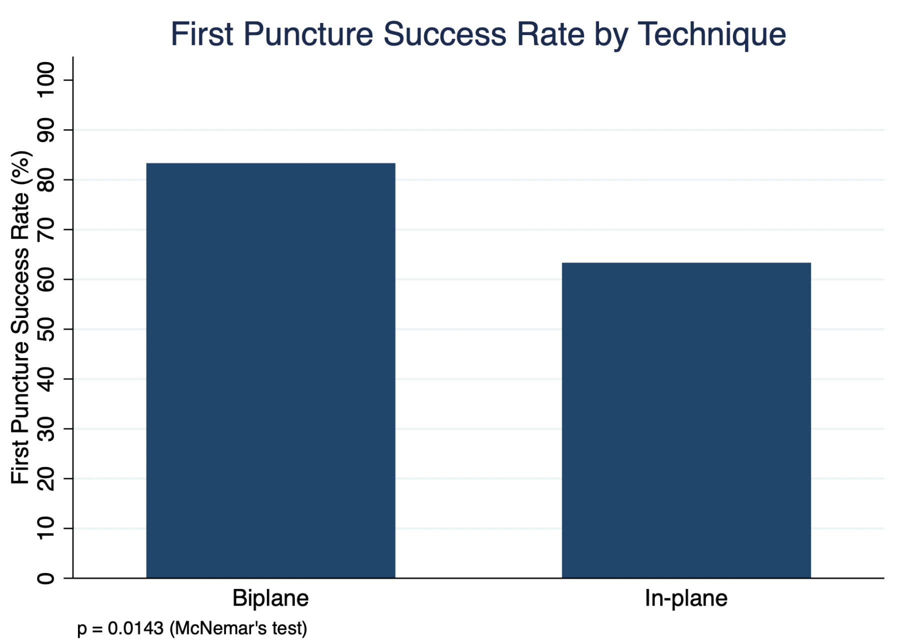

Figure 6. First puncture success rate by technique. This figure compares the first puncture success rates between the in-plane and biplane techniques. The biplane technique demonstrated a significantly higher first puncture success rate (83%) compared with the in-plane technique (63%), as confirmed by McNemar's test ($P = 0.01$).

One could argue that there might have been a learning effect or that the randomized order of execution methods— in-plane then biplane versus biplane then in-plane—may have influenced the outcome of this study. However, this assumption was disproven statistically. No significant differences based on the order of intervention were observed.

In terms of subjective impressions, the post-intervention questionnaire revealed that the majority favored the biplane approach for USBx. They reported that although the biplane technique felt more mentally demanding—due to lack of experience and unfamiliarity with three-dimensional thinking—they also felt safer and substantially more confident compared with the in-plane technique, due to the additional information provided. While very experienced operators may argue that the simultaneous additional axis is unnecessary, the biplane technique appears to be the method of choice for less experienced users. This conclusion was also drawn in the previously mentioned study comparing single-plane and biplane ultrasound-guided central venous catheterization.[13]

Another key criterion is patient comfort. Although the study was conducted on phantoms and definitive conclusions cannot be drawn, it is likely that with sufficient practice and experience using the biplane technique, patient comfort would be comparable to that of biopsies performed using the in-plane approach. In fact, given the expected lower complication rates and higher first-puncture success rate associated with the biplane approach, patient comfort may even be substantially improved by comparison.

In addition to the arguments above, it is also important to consider the limitations of the present study. First and foremost, the sample size and the lack of experienced ultrasound operators substantially limit the ability to determine clear superiority between the two techniques. The study's generalizability is restricted by the high proportion of trainee doctors, as only 13% of participants were specialists with extensive experience. The biopsies were conducted on phantoms and did not fully replicate real-life settings or actual patients. It should also be emphasized that only the biopsy of solid lesions was simulated; non-mass or partly solid lesions were not examined, which further limits the generalizability of the findings. However, it is reasonable to assume that real-time imaging of both short- and long-axis views may aid in navigating around and avoiding the puncture of critical structures such as nerves, vessels, bones, muscles, and fascial planes, potentially reducing complication rates even in non-mass biopsies.[18]

Future studies should consider incorporating tissue models or clinical trials to better validate these findings. Another limitation of the current study is that only the freehand technique was used. Consequently, the potential drawbacks or advantages of the biplane approach in procedures where ultrasound imaging is performed separately from the biopsy have not been explored.

Overall, considering the results of this study and those of the other referenced in-plane versus biplane study, there appears to be a clear trend favoring the biplane technique—at least in the hands of less-experienced operators. Nevertheless, due to the limitations and objections outlined above, absolute superiority cannot be asserted with certainty. However, it can be reasonably argued that while experienced operators may benefit only marginally from the additional axis, the biplane approach appears to be the method of choice for beginners and intermediate users. Incorporating biplane imaging into training programs for less-experienced operators could enhance procedural success rates and safety. Although the increased cognitive effort required for biplane imaging may initially discourage adoption, this challenge could be mitigated through targeted training and continued practice.

In conclusion, in this study, the biplane technique in USBx was substantially superior in terms of total biopsy attempts and first-puncture success rate when compared with the in-plane approach, potentially offering safety and efficiency advantages—particularly in the hands of less-experienced operators. Further research involving larger sample sizes, varying levels of operator experience, and real-world clinical settings is essential to confirm the potential superiority of biplane imaging in USBx.

Footnotes

Conflict of interest disclosure

The authors declared no conflicts of interest.

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