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Use of a soft guiding template and laser device improves the success rate of computed tomography-guided bone biopsies and reduces radiation exposure

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Abstract

Background Precision and operator expertise are critical for bone tumour biopsies. In this study, we investigated the impact of combining a soft guiding template with a laser device on the success rate of computed tomography (CT)-guided bone biopsies and the associated radiation dose.

Methods A cohort of 114 patients with bone tumours requiring CT-guided biopsies were assigned to the auxiliary device group, utilising a soft guiding template and a laser device. Another 197 patients (control group) underwent biopsies with conventional guiding templates. The $\chi 2$ test compared biopsy success rates and concordance rates between biopsy findings and surgical outcomes. Biopsy success rates for limb bones, limb girdles, and axial bones were also compared. Independent sample t-tests analysed differences in age, volume CT dose index ($CTDI_{vol}$), dose-length product (DLP), and effective dose (ED) between groups, as well as for limb bones, limb girdles, and axial bones individually.

Results The biopsy success rate in the auxiliary device group (85.09%) was significantly higher than in the control group (74.62%; $P=0.032$). No significant differences were observed for limb girdles ($P=0.40$) or axial bones ($P=0.19$). However, the biopsy success rate for limb bones was significantly higher in the auxiliary device group (85.51%) than in the control group (70.87%; $P=0.028$). The concordance rate between biopsy findings and surgical outcomes did not differ significantly ($P=1.00$). $CTDI_{vol}$ showed no significant differences for limb girdles ($P=0.66$), limb bones ($P=0.23$), or axial bones ($P=0.8$). While DLP ($P=0.41$)and ED ($P=0.42$) showed no significant differences for limb girdles, they were significantly lower for limb bones (DLP: $P=0.012$; ED: $P=0.012$) and axial bones (DLP: $P=0.005$; ED: $P=0.002$) in the auxiliary device group.

Conclusion The combination of a soft guiding template and laser device significantly improved the success rate of CT-guided bone biopsies, providing a solid histological foundation for early and accurate diagnosis. Furthermore, these devices reduced the associated radiation dose, lowering radiation-related risks for patients.

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Keywords CT-guided biopsies, Bone tumours, Radiation dose, Soft guiding template, Laser

Background

Image-guided percutaneous bone biopsy enables real-time visualisation of the needle's position, making it the preferred method for the definitive diagnosis of bone tumours and is widely utilised [1]. Currently, common imaging guidance techniques for percutaneous bone biopsy include computed tomography (CT) guidance, magnetic resonance (MR) guidance, and ultrasound guidance. Ultrasound-guided percutaneous bone biopsy is particularly suitable for superficial lesions and those with compromised cortical bone. However, it is also the imaging guidance technique that demands the highest level of operator expertise [2], which limits its scope of application and makes the biopsy success rate uncertain. MR-guided percutaneous bone biopsy has advantages in visualising certain bone tumours; however, it is constrained by the duration of the procedure and the cost [3], making it difficult to implement on a large scale. Therefore, CT-guided percutaneous bone biopsy is the preferred diagnostic method for bone tumours. This minimally invasive technique offers substantial benefits with minimal risks, including bone structure preservation, minimal soft tissue damage, avoidance of general anaesthesia, shortened hospital stays, reduced medical expenses, minimal postoperative complications, and rare tumour dissemination [4–6]. The primary objective of percutaneous bone biopsy is to distinguish between benign and malignant bone tumours, guiding clinicians to formulate appropriate treatment strategies. Benign bone tumours can be managed or treated with curettage, while malignant tumours typically require extensive resection and may require adjunctive radiotherapy and chemotherapy [7, 8]. For an accurate diagnosis, CT-guided biopsy specimens must contain adequate viable tumour tissue for pathological analysis [9]. However, in bone tumours, particularly those with intact cortices, accessing the medullary cavity via a drilled cortical hole limits needle manoeuvrability post-insertion, thereby underscoring the criticality of precise alignment of the puncture site and angle with the intended trajectory. Generally, achieving such precision relies heavily on operator expertise and dexterity [10, 11].

CT-guided percutaneous bone biopsy requires multiple CT scans of the puncture site to monitor the position of the biopsy needle, with each scan imparting a radiation dose equivalent to that of a standard CT scan, thereby exposing patients to potential radiation damage. Research by Kihira et al. [10] indicates that the average dose-length product (DLP) for CT-guided percutaneous bone biopsy can range from 971 to 1203 mGy×cm. There are two methods to reduce radiation dose: one is to use low-dose scanning without compromising the procedure to decrease the radiation dose per scan [12, 13], and the other is to minimise the total number of scans to reduce the overall radiation dose.

In this study, we aimed to employ a soft guiding template and an in-house developed laser device to enhance puncture site accuracy and establish precise needle insertion angles. The primary objective of employing these tools was to achieve precise targeting, procure a higher yield of tumour cells, and enhance biopsy success rates. Simultaneously, we aimed to reduce the radiation dose, thereby decreasing the likelihood of patients suffering from radiation-related harm.

Methods

Participants

This retrospective monocentric study was approved by the institutional review board (2024 Medical Ethics Review Committee 152), and written informed consent was obtained from each patient. A total of 506 patients who underwent CT-guided bone biopsy at Tianjin Hospital between January 2023 and January 2024 were recruited. After excluding 167 cases handled by external teams and 28 cases where biopsy was hindered owing to personal reasons or coagulation abnormalities, 311 cases were ultimately included. Among these, patients from beds 1 to 12 in the bone and soft tissue tumour ward were included in the auxiliary device group, totalling 114 cases. These patients utilised a soft guiding template and a laser device for biopsy assistance. Patients from beds 12 to 36 in the same ward were included in the control group, totalling 197 cases, which did not employ any auxiliary devices, thus constituting the control group (Fig. 1).

All included cases underwent biopsy procedures by the same team, consisting of:

- Operator 1 (XL W): A radiologist with 13 years of experience.
- Operator 2 (ZL J): A radiologist with 2 years of experience.
- Operator 3 (JY Z): An orthopaedic surgeon with 15 years of experience.
- Operator 4 (JW L): An orthopaedic surgeon with 10 years of experience.
- Operator 5 (W W): An orthopaedic surgeon with 3 years of experience.

Preparation of auxiliary equipment

Soft guiding template

The soft guiding template was prepared by mixing 5 g of barium sulphate (Type II) dry suspension (Qingdao Red

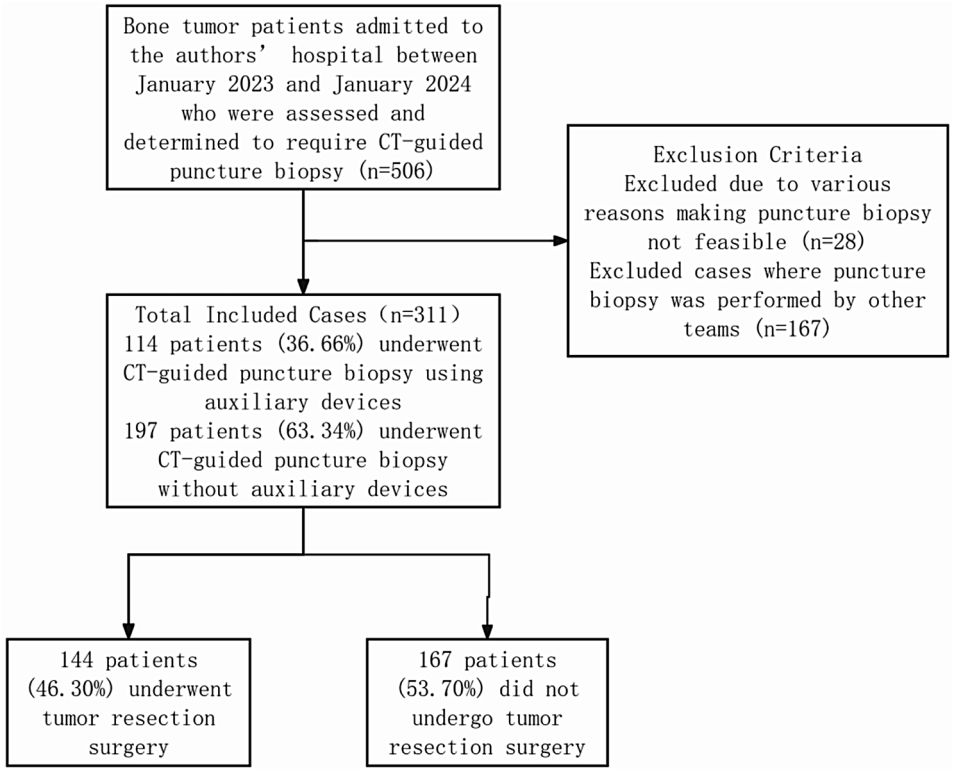

Fig. 1 Study flowchart for patients undergoing CT-guided bone biopsy

Butterfly Precision Materials Co., Ltd., China) with 85 g of α, ω-dihydroxyl polydimethylsiloxane (Hoshine Silicon Industry Co., Ltd., China) to form a pre-catalyst viscous liquid compound. This mixture was then combined with 5 g of dimethyl silicone oil (Shin-Etsu Chemical Co., Ltd., China) and 5 g of dibutyltin dilaurate (Foshan Keneng New Materials Co., Ltd., China) to produce a final viscous liquid compound. Subsequently, the generated compound was poured into a pre-fabricated mould and solidified to produce a soft self-adhesive silicone template. This template conformed closely to the skin, preventing positioning deviations caused by uneven body surfaces, making it suitable for CT-guided percutaneous biopsies at most body locations. It also facilitated precise selection of epidermal puncture points through its perforations (Fig. 2A-D). Moreover, the device can be reused after undergoing routine sterilisation, thus preventing additional medical expenses for patients.

Laser device

Generally, the puncture angle is determined by the built-in CT gantry lasers, which rotate the gantry to a pre-set angle. However, this approach only aids in positioning the rotation angle of the body's axial plane and lacks three-dimensional (3D) guidance. Furthermore, it requires operator proximity to the scanning gantry, potentially impeding the procedure. In this study, the laser device was enhanced by incorporating two laser projectors (DUKAL1, Shenzhen ATuMan Precision Machinery Technology Co., Ltd., China) positioned on either side of the CT table. The laser angle projector displayed the angle between the laser line and the horizontal plane on the screen and simultaneously emitted another laser line perpendicular to it. The operator manually adjusted the projected laser lines to ensure that the displayed angle matched the preset value and that the perpendicular laser line was parallel to the edge of the adjacent CT table, providing guidance for the needle insertion angle (Figs. 3A, B). During the procedure, the operator aligned the biopsy needle with the two lasers to puncture at the specified angle.

CT-guided biopsy

In the control group, a conventional guiding template was positioned on the skin surface at the pre-determined puncture site. Conversely, in the auxiliary device group, a soft guiding template was utilised. CT scanning was conducted using a 64-slice CT scanner (Discovery CT750 HD, GE Healthcare, USA). The equipment undergoes quality control (QC) every three months by an engineer from GE Healthcare(J L, A GE Healthcare with 15 years of experience), encompassing an area extending 3 cm beyond the tumour both superiorly and inferiorly. The scanning parameters included a tube voltage of 100 kV,

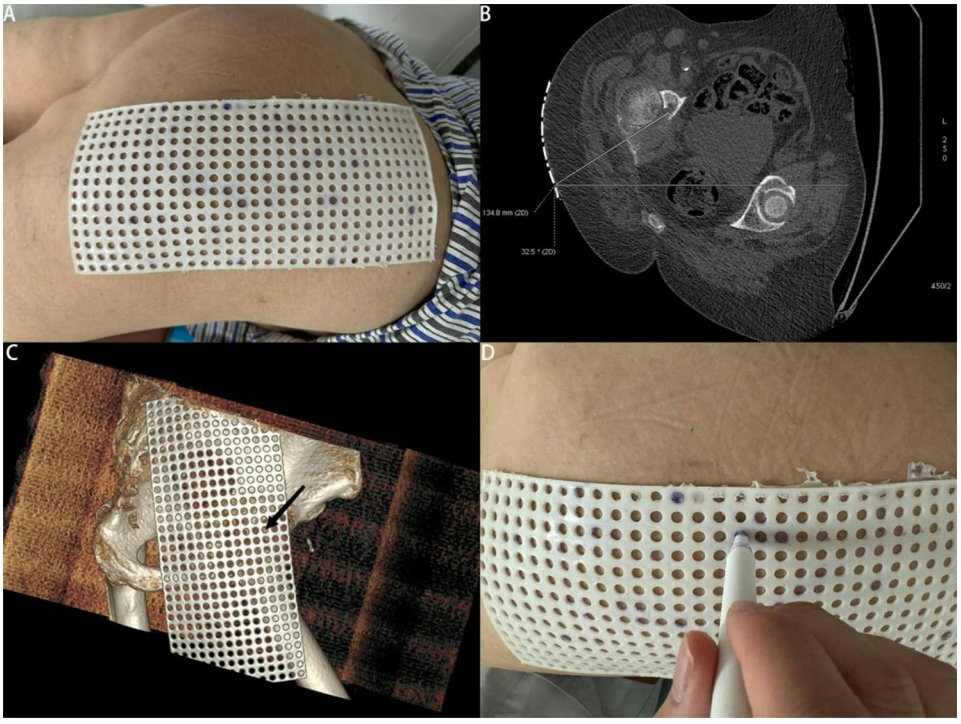

Fig. 2 A 63-year-old woman presenting with bone destruction in the right acetabulum. (**A**) Computed tomography (CT) scan positioning facilitated by the soft guiding template. (**B**) Identification of the puncture point and determination of puncture angle and distance on the CT image. (**C**) Volume reconstruction illustrating the puncture point (black arrow). (**D**) Localization of the puncture point on the patient's body surface guided by the CT image

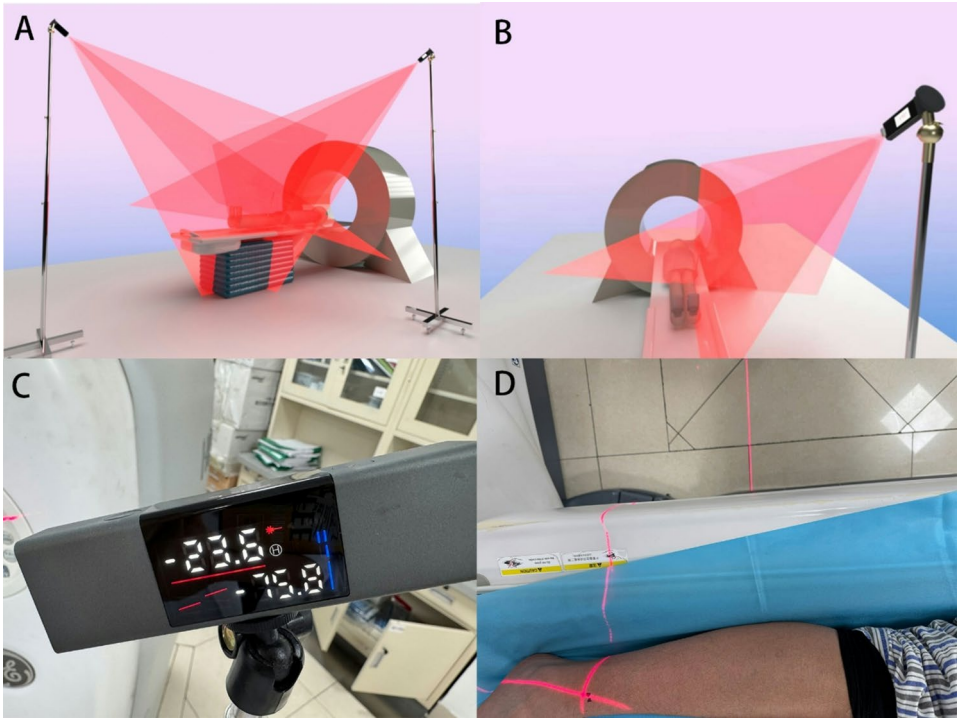

Fig. 3 Diagrams of the auxiliary laser device. **A**, **B** The laser positioning device emits parallel and perpendicular laser beams to the puncture point at a predetermined angle, aiding in the adjustment of the needle's insertion angle. **C**, **D** Adjust the angle of the laser positioning device to the set angle, ensuring that the other laser line is parallel to the long and short sides of the CT table

an effective tube current of 70 mA, a pitch of 1, a reconstruction slice thickness of 0.625 mm, a reconstruction slice interval of 0.625 mm, and a field of view set to Large Body. Subsequently, the puncture site was marked on the skin based on the acquired images. In the auxiliary device group, the laser device was also employed to determine the puncture angle (Fig. 2A-D). Local anaesthesia was administered using 2% lidocaine hydrochloride (Shanghai Harvest Pharmaceutical Co., Ltd., China) from the skin to the bone cortex or the soft tissue near the tumour edge at the specified angle. A disposable biopsy needle (PAG0915, STERYLAB S.r.l, Italy) was utilised to extract the biopsy specimens (Fig. 4A, B). These specimens were fixed in formaldehyde and sent to the pathology department for evaluation by an experienced bone and soft tissue pathologist. Some patients underwent bone tumour resection surgery at our hospital following the biopsy, with their postoperative pathology results serving as the gold standard for diagnosis.

The pathologist assessed the biopsy specimens, and those allowing a definitive diagnosis were categorised as "diagnostic." However, if a definitive diagnosis could not be made but the nature of the lesion (benign or malignant) could be determined, the specimen was categorised as "acceptable." Furthermore, specimens that did not allow for a definitive diagnosis or determination of the nature of the lesion were categorised as "non-diagnostic." In this study, biopsies categorised as "diagnostic" or "acceptable" were deemed "successful," while those categorised as "non-diagnostic" were considered "failed."

All included cases underwent biopsy specimens assessed by the same team, consisting of:

- Pathologist 1 (GY X): A pathologist with 16 years of experience.
- Pathologist 2 (SH D): A radiologist with 13 years of experience.

Radiation dose assessment

Radiation dose data for all CT-guided biopsy cases were extracted from the picture archiving and communication system, including the volume CT dose index ($CTDI_{vol}$) and dose-length product (DLP). The effective dose (ED) was calculated using the formula: $ED = k \times DLP$, where k represents the tissue conversion factor derived from reference Table [14]. This study only accounted for the radiation dose incurred during the biopsy procedure, excluding doses from the initial localisation and postoperative scans.

Operator satisfaction

Following each procedure involving the auxiliary device group, operators evaluated their satisfaction with the role of the auxiliary device during surgery on a scale from 1 to 5, based on their experience (1: very dissatisfied, 2: dissatisfied, 3: neutral, 4:satisfied, 5: very satisfied).

Statistical analysis

Data were analysed using Statistical Package for the Social Sciences (version 29.0; IBM Corp., USA). Normally distributed quantitative data were expressed as the mean ± standard deviation ($x \pm s$). The χ^2 test was utilised to compare sex distribution, tumour location, puncture success rate, and concordance rate between successful biopsies and surgical outcomes across the two groups. Furthermore, the puncture success rates for limb bones, limb-girdle bones, and axial bones in both groups were compared using the same test. The independent samples t-test was applied to assess differences in age, $CTDI_{vol}$, DLP, and ED between the auxiliary device and control groups, as well as the disparities in $CTDI_{vol}$, DLP, and ED for limb bones, limb-girdle bones, and axial bones between the two groups. Statistical significance was set at $P < 0.05$. All satisfaction surveys from the auxiliary device group were compiled, and the ratings were statistically analysed.

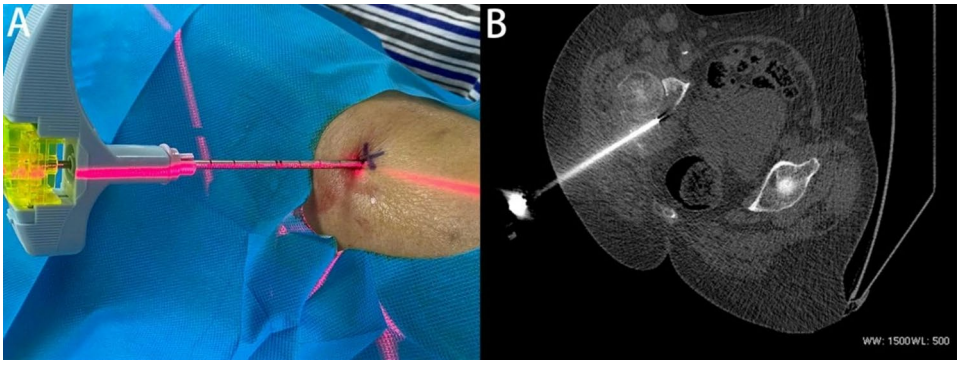

Fig. 4 Featuring the same patient as depicted in Fig. 2. (**A**) Alignment of the biopsy needle with the positioning lasers. (**B**) CT scan showing the biopsy needle aligned with the preset puncture direction

Table 1 Patient characteristics

Group	Age (years)	Sex		
		Woman	Man	Total
Auxiliary Device Group	50.91 ± 18.76	55	59	114
Control Group	49.51 ± 20.31	105	92	197
Total	50.00 ± 19.7	160	151	311
t-value	-0.604			
χ^2 value		0.738		
P-value	0.546	0.412		

Results

General information

The age range of the 311 patients spanned from 5 to 83 years. Among them, 15 patients were under the age of 14, constituting the adolescent patient. There were no statistically significant differences in sex or age distributions between the two groups (Table 1).

Summary of puncture biopsy success rates

The most frequent diagnoses among the "diagnostic" cases were metastatic tumours (20.6%, 64/311), followed by non-tumorous lesions (9.6%, 30/311), and enchondromas (8.0%, 25/311). Among the 30 non-tumorous lesions, there were 24 inflammatory lesions, 2 cases of coagulative necrosis, 1 case of bone infarction, 2 cases of Paget disease, and 1 simple fracture.

The success rates of puncture biopsies for both the auxiliary device group and the control group, as well as the diagnostic success rates for each subgroup, are listed in Table 2.

Summary of patients undergoing surgical resection for bone tumours

Among the 144 cases where lesions were surgically excised, the most prevalent diagnoses were enchondroma (20 cases) and metastatic tumours (18 cases). The proportions of "diagnostic," "acceptable," and "non-diagnostic" cases were 75.69% (109/144), 8.33% (12/144), and 15.97% (23/144), respectively. Within the auxiliary device group, 56 patients underwent surgical resection, with 50 cases classified as successful biopsies. The concordance rate between biopsy outcomes and the gold standard was 90% (45/50). The remaining six cases were categorised as "non-diagnostic," including two bone cysts, one intermediate lesion, one vascular lymphangioma, one chondromyxoid fibroma, and one non-tumorous lesion (diagnosed as intraosseous fat necrosis with fibrosis, calcification, and focal bone infarction). Conversely, in the control group, 88 patients underwent surgical resection, with 71 successful biopsy cases. The concordance rate between biopsy outcomes and the gold standard was 90.14% (64/71). The remaining 17 cases were classified as "non-diagnostic," involving two aneurysmal bone cysts, one haemangioma, three benign lesions, one metastatic tumour, one chondromyxoid fibroma, one non-tumorous lesion (no tumour cells found in surgical specimens), three lipo-sclerosing myxofibrous tumours, one lipoma, one intraosseous ganglion cyst, one fibrous dysplasia of bone, one osteochondroma, and one bone cyst.

The concordance rates between successful biopsy cases and surgical results were 90% (45/50) in the auxiliary device group and 90.14% (64/71) in the control group, showing no statistically significant difference ($\chi^2 = 0.001$, $P = 1.00$).

Comparison of radiation dose between auxiliary device and control groups

The $CTDI_{vol}$, DLP, and ED, along with their statistical data for the auxiliary device and control groups, are delineated in Table 3.

Complications

One patient with a lesion located in the rib developed pneumothorax postoperatively. Upon follow-up, the auxiliary device group did not experience any complications related to auxiliary devices, such as allergic reactions.

Table 2 Success rates of punctures for each group

		Diagnostic	Acceptable	Successful (Diagnostic & Acceptable)	Failed (Non-diagnostic)
Limb Bones	Auxiliary Device Group	85.51% (59/69)	14.49% (10/69)	85.51% (59/69)	14.49% (10/69)
	Control Group	65.05% (67/103)	5.83% (6/103)	70.87% (73/103)	29.13% (30/103)
	P-value			0.028	
Limb Girdles	Auxiliary Device Group	63.64% (7/11)	9.09% (1/11)	72.72% (8/11)	27.27% (3/11)
	Control Group	81.25% (26/32)	3.13% (1/32)	84.38% (27/32)	15.63% (5/32)
	P-value			0.40	
Axial Bones	Auxiliary Device Group	86.67% (26/30)	13.33% (4/30)	88.24% (30/34)	13.33% (4/30)
	Control Group	70.97% (44/62)	4.84% (3/62)	75.81% (47/62)	24.19% (15/62)
	P-value			0.19	
Total	Auxiliary Device Group	71.93% (82/114)	13.16% (15/114)	85.09% (97/114)	14.91% (17/114)
	Control Group	69.5% (137/197)	5.1% (10/197)	74.62% (147/197)	25.4% (50/197)
	P-value			0.032	

Table 3 $CTDI_{vol}$, DLP, and ED data for puncture biopsies in different tumour locations for the auxiliary device and control groups (units provided)

		Limb Girdles	Limb Bones	Axial Bones	All Cases	*P*-value
$CTDI_{vol}$ (mGy)	Control Group	10.48 ± 2.96	10.39 ± 2.65	9.99 ± 1.70	10.28 ± 2.45	0.27
	Auxiliary Device Group	10.95 ± 2.91	10.97 ± 3.68	9.88 ± 2.27	10.64 ± 3.27	
P-value		0.66	0.23	0.8		
DLP (mGy×cm)	Control Group	466.05 ± 191.38	367.30 ± 229.05	602.70 ± 267.76	457.42 ± 257.62	<0.001
	Auxiliary Device Group	536.78 ± 355.92	288.43 ± 175.36	433.94 ± 280.00	353.37 ± 246.46	
P-value		0.41	0.012	0.005		
ED (mSv)	Control Group	7.01 ± 2.85	5.47 ± 3.41	8.71 ± 3.99	6.74 ± 3.80	<0.001
	Auxiliary Device Group	8.05 ± 5.33	4.23 ± 2.61	5.99 ± 3.93	5.13 ± 3.56	
P-value		0.42	0.012	0.002		

Table 4 Success rates and satisfaction levels of biopsies performed by each operator

	Operator 1	Operator 2	Operator 3	Operator 4	Operator 5
Auxiliary Device Group	84.44% (38/45)	92.31% (12/13)	79.17% (19/24)	87.5% (21/24)	87.5% (7/8)
Control Group	76.62 (59/77)	73.68% (14/19)	75.93% (41/54)	66.67% (18/27)	75% (15/20)
Satisfaction	4.44	4.33	4.67	4.42	4.25

Success rates of punctures and satisfaction scores for auxiliary devices by each operator

The success rates and satisfaction scores for auxiliary devices, as selected by each operator, are shown in Table 4.

Discussion

According to various reports, the diagnostic accuracy of CT-guided percutaneous biopsy varies significantly, with diagnostic rates ranging from 49 to 98% and false-negative rates between 2% and 8% [15–19]. In this study, the puncture success rates were 85% in the auxiliary device group and 75% in the control group, indicating a higher success rate in the former. We employed a soft guiding template to enhance the accuracy of the puncture entry point, supplemented by a laser device projecting beams at a predetermined angle. The entry angle of the puncture needle was ensured by aligning it with the laser beams. The combination of these two tools helped match the puncture entry point and angle to the pre-set path, thereby ensuring that the biopsy sample was procured from the targeted tissue visualised in the CT images. Thus, these findings confirmed a higher puncture success rate in patients using the auxiliary devices.

Limited studies exist on the impact of puncture position and angle on biopsy success rates. Despite the recent increase in the use of 3D-printed templates for biopsy and seed implantation—which can effectively improve puncture accuracy [20, 21]—these templates are costly and complex to prepare, limiting their widespread adoption. Moreover, most 3D-printed templates are designed for lung biopsies and are less suitable for intraosseous lesions that have not breached the cortex. Furthermore, the puncture process through the bone cortex can cause the template to shift, leading to inaccurate positioning. In contrast, the laser device used in this study offers non-contact auxiliary positioning, making it less susceptible to interference during the puncture process and more suitable for musculoskeletal system biopsies.

Certain pathological lesions, such as lymphomas, have lower diagnostic rates compared to those of other malignancies, possibly owing to compression artifacts during biopsy sampling [22]. Among benign lesions, histiocytosis typically exhibits a lower diagnostic rate [23]. Cystic lesions and tumours with high necrotic content often result in lower diagnostic rates because of difficulties in obtaining effective samples. Furthermore, lesions with a rich blood supply may yield lower diagnostic rates as the sample can be diluted with blood. Consistent with the above, lesions such as aneurysmal bone cysts, haemangioendotheliomas, haemangiomas, and intraosseous ganglion cysts showed a 100% failure rate in both the auxiliary device and control groups in this study. We posit that this might be because these lesions predominantly consist of liquid components, making it challenging to extract effective tissue samples through puncture biopsy, thus increasing the failure rate.

In this study, there were four cases of failed biopsies where the pathological results of the surgical specimens provided only qualitative diagnoses rather than definitive ones. Among these, one case was classified as an "intermediate lesion" and three as "benign lesions." This likely stemmed from the lack of distinctive features within the lesions, making it difficult to establish a definite diagnosis even from surgical specimens. Moreover, as biopsy samples are localised, obtaining a conclusive diagnosis becomes even more challenging.

Notably, the biopsy success rate for sclerosing epithelioid fibrosarcoma was 50% (3/6), with all successful cases belonging to the control group. We speculate that

this may be attributed to the complex composition of this tumour type [24, 25], where biopsy samples may not adequately represent the entire lesion, leading to a lower success rate. Specifically, in the auxiliary device group, one biopsy failed for chondroblastoma, likely owing to procedural errors. In the control group, one patient with a metastatic tumour experienced biopsy failure, possibly because the biopsy needle targeted a necrotic tumour area, resulting in a sample with insufficient diagnostic components for a definitive diagnosis.

Studies suggest that approximately 1% of newly diagnosed cancers each year are related to medical radiation exposure [26, 27]. The dose-response curve between radiation exposure and cancer risk is generally considered linear [28]. Bosch et al. [29] reported that the risk of haematological malignancies increased by 43% per CT scan overall, with increases of 42% and 48%, for lymphoid and myeloid malignancies, respectively, including acute leukaemia. Previous studies have shown significant variations in radiation doses for CT-guided percutaneous bone biopsy kits. For instance, Sebastian et al. [9] reported an average DLP ranging from 296 to 659 mGy×cm, while Yang et al. [30] reported a median DLP of 733 mGy×cm, and Kihira et al. [10] reported an average DLP of up to 752–1317 mGy×cm. In this study, the average DLP was 288–603 mGy×cm, which is lower than the radiation doses reported in some studies. The wide variation in reported radiation doses across studies may be owing to differences in CT scanning parameters and puncture sites. In this study, there was no statistically significant difference in $CTDI_{vol}$ between the auxiliary device group and the control group, indicating that the CT scanning parameters were consistent, with little variation in radiation doses. Increased radiation exposure during CT-guided percutaneous biopsies is primarily attributed to the repeated CT scans required to adjust and confirm the needle direction [11]. In this study, the use of a soft guiding template and a laser device for CT-guided bone biopsies resulted in lower DLPs and EDs for biopsies of limb bones and axial bones compared to those in the control group.

This finding is likely because the auxiliary devices improved the accuracy of the needle entry point and angle, thereby reducing the need for multiple scans and consequently decreasing overall radiation exposure. However, there was no significant difference in the radiation dose between the two groups for limb girdles. This may be attributed to the irregular shape and small size of these bones, where minor deviations in puncture position can affect the outcome, necessitating multiple confirmations of the needle angle and increasing the number of scans.

Despite its strengths, this study has some limitations. First, the total number of cases is relatively small, which, combined with the random assignment of groups, could lead to an uneven distribution of certain diseases between the two groups. Secondly, the laser device used in this study was fixed with a stand that had poor stability, potentially causing slight deviations in the laser beam. Future research should thus focus on enhancing the stability of this laser device. Lastly, the auxiliary device in this study only improved the accuracy of the puncture entry point and direction. However, the selection of the entry point and direction still depended on the imaging characteristics of the bone tumour on CT images. Future studies are thus needed to investigate whether combining CT and MR images can further improve the biopsy success rate.

Conclusion

Combining a soft guiding template with a laser device can enhance the accuracy of the puncture entry point and angle in CT-guided bone biopsies, thereby improving biopsy success rates. This approach also minimises the need for repeated scans to adjust the needle angle, resulting in lower radiation exposure for patients during the procedure. Given these benefits, the proposed auxiliary devices demonstrate potential for broader adoption.

Abbreviations

CT	Computed tomography
$CTDI_{vol}$	Volume CT dose index
DLP	Dose-length product
ED	Effective dose
3D	Three-dimensional
MR	Magnetic resonance

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Author contributions

Xl.W and Xh.M wrote the main manuscript text. Xl.W, Zl.J, Jy.Z, Jw.L, W.W, Zy.S perform CT-guided puncture biopsy procedure. Gy.X, Sh.D perform pathological analysis on specimens. All authors reviewed the manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study was approved by the institutional review board (2024 Medical Ethics Review Committee 152, Tianjin Hospital Medical Ethics Committee, Tianjin Hospital, China), and we obtained written informed consent from each patient.

Consent for publication
Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

Competing interests
The authors declare no competing interests.

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References

1. Filippiadis DK, Charalampopoulos G, Mazioti A, Keramida K, Kelekis A. Bone and soft-tissue biopsies: What you need to know. Semin Intervent Radiol. 2018;35:215–20. https://doi.org/10.1055/s-0038-1669467.
2. Ponti F, Arioli A, Longo C, Miceli M, Colangeli M, Papalexis N, et al. Ultrasound-guided percutaneous bone biopsy: Feasibility, diagnostic yield and technical notes. Diagnostics (Basel). 2023;13:1773. https://doi.org/10.3390/diagnostics13101773.
3. Spinnato P, Colangeli M, Rinaldi R, Ponti F. Percutaneous CT-guided bone biopsies: Indications, feasibility and diagnostic yield in the different skeletal sites—from the skull to the toe. Diagnostics (Basel). 2023;13:2350. https://doi.org/10.3390/diagnostics13142350.
4. Gami A, Shah A, Shankaralingappa S, Salunke AA, Gandhi J, Patel K, et al. Does an excision of needle bone biopsy tract affect the prognosis in patients with primary bone tumor? J Orthop. 2024;48:13–9. https://doi.org/10.1016/j.jor.2023.11.039.
5. Mills MK, Leake RL, Crawford AM, Soltanolkotabi M, Hansford BG. Concepts in musculoskeletal bone and soft tissue biopsy. Semin Musculoskelet Radiol. 2021;25:711–24. https://doi.org/10.1055/s-0041-1735471.
6. Ariizumi T, Kawashima H, Yamagishi T, Oike N, Murayama Y, Umezu H, et al. Diagnostic accuracy of fine needle aspiration cytology and core needle biopsy in bone and soft tissue tumor: A comparative study of the image-guided and blindly performed procedure. Ann Diagn Pathol. 2022;59:151936.
7. Horstmann PF, Hettwer WH, Petersen MM. Treatment of benign and borderline bone tumors with combined curettage and bone defect reconstruction. J Orthop Surg (Hong Kong). 2018;26:2309499018774929. https://doi.org/10.1177/2309499018774929.
8. Gerrand C, Athanasou N, Brennan B, Grimer R, Judson I, Morland B, et al. UK guidelines for the management of bone sarcomas. Clin Sarcoma Res. 2016;6:7. https://doi.org/10.1186/s13569-016-0047-1.
9. Zensen S, Selvaretnam S, Opitz M, Bos D, Haubold J, Theysohn J, et al. Differences in radiation exposure of CT-guided percutaneous manual and powered drill bone biopsy. Cardiovasc Intervent Radiol. 2021;44:1430–8. https://doi.org/10.1007/s00270-021-02851-z.
10. Kihira S, Lee A, Aggarwal A, Pawha P, Doshi A. Reduction of radiation dose and scanning time while preserving diagnostic yield: A comparison of battery-powered and manual bone biopsy systems. AJNR Am J Neuroradiol. 2020;41:387–92. https://doi.org/10.3174/ajnr.A6428.
11. Xin B, Liu D, Lu P, Cao S, Bai G, Gao P, et al. The application of ultrasonography-computed tomography fusion navigation technology in complex bone tumor biopsy: A randomized double-blind controlled trial. World Neurosurg. 2024;181:e963–9. https://doi.org/10.1016/j.wneu.2023.11.021.
12. Li EL, Ma AL, Wang T, Fu YF, Liu HY, Li GC. Low-dose versus standard-dose computed tomography-guided biopsy for pulmonary nodules: A randomized controlled trial. J Cardiothorac Surg. 2023;18:86. https://doi.org/10.1186/s13019-023-02183-8.
13. Cohen MG, McMahon CJ, Kung JW, Wu JS. Comparison of battery-powered and manual bone biopsy systems for core needle biopsy of sclerotic bone lesions. AJR Am J Roentgenol. 2016;206:W83–6. https://doi.org/10.2214/AJR.15.15067.
14. Valentin J, International Commission on Radiation Protection. Managing patient dose in multi-detector computed tomography (MDCT). Ann ICRP. 2007;37:1–iii. https://doi.org/10.1016/j.icrp.2007.09.001. ICRP Publication 102.
15. Burke MC, Garg A, Youngner JM, Deshmukh SD, Omar IM. Initial experience with dual-energy computed tomography-guided bone biopsies of bone lesions that are occult on monoenergetic CT. Skeletal Radiol. 2019;48:605–13. https://doi.org/10.1007/s00256-018-3087-1.
16. Hegde V, Burke ZDC, Park HY, Zoller SD, Johansen D, Kelley BV, et al. Is core needle biopsy reliable in differentiating between aggressive benign and malignant radiolucent bone tumors? Clin Orthop Relat Res. 2018;476:568–77. https://doi.org/10.1007/s11999.0000000000000062.
17. Mitsuyoshi G, Naito N, Kawai A, Kunisada T, Yoshida A, Yanai H, et al. Accurate diagnosis of musculoskeletal lesions by core needle biopsy. J Surg Oncol. 2006;94:21–7. https://doi.org/10.1002/jso.20504.
18. Wu JS, Goldsmith JD, Horwich PJ, Shetty SK, Hochman MG. Bone and soft-tissue lesions: What factors affect diagnostic yield of image-guided core-needle biopsy? Radiology. 2008;248:962–70.
19. Kilpatrick SE, Cappellari JO, Bos GD, Gold SH, Ward WG. Is fine-needle aspiration biopsy a practical alternative to open biopsy for the primary diagnosis of sarcoma? Experience with 140 patients. Am J Clin Pathol. 2001;115:59–68. https://doi.org/10.1309/YN14-K8U4-5FLJ-DGJE.
20. Ji Z, Sun H, Jiang Y, Guo F, Peng R, Fan J, et al. Comparative study for CT-guided ^{125}I seed implantation assisted by 3D printing coplanar and non-coplanar template in peripheral lung cancer. J Contemp Brachytherapy. 2019;11:169–73. https://doi.org/10.5114/jcb.2019.84503.
21. Chen E, Zhang Y, Zhang H, Jia C, Liang Y, Wang J. Dosimetry study of three-dimensional print template for 125I implantation therapy. Radiat Oncol. 2021;16:115. https://doi.org/10.1186/s13014-021-01845-y.
22. Chang CY, Huang AJ, Bredella MA, Torriani M, Halpern EF, et al. Percutaneous CT-guided needle biopsies of musculoskeletal tumors: A 5-year analysis of non-diagnostic biopsies. Skeletal Radiol. 2015;44:1795–803. https://doi.org/10.1007/s00256-015-2235-0.
23. Yang J, Frassica FJ, Fayad L, Clark DP, Weber KL. Analysis of nondiagnostic results after image-guided needle biopsies of musculoskeletal lesions. Clin Orthop Relat Res. 2010;468:3103–11. https://doi.org/10.1007/s11999-010-1337-1.
24. Barnds B, Grote C, Mettman D, Templeton K. Liposclerosing myxofibrous tumor in a patient with prostate cancer. JBJS Case Connect. 2019;9:e0411. https://doi.org/10.2106/JBJS.CC.18.00411.
25. Ploof J, Shaikh H, Melli J, Jour G, Turtz A. Liposclerosing myxofibrous tumor of the cranial vault: A case report. Neurosurgery. 2019;84:E207–10. https://doi.org/10.1093/neuros/nyy071.
26. Lim H, Choi J, Kim JH, Cheong HK, Ha M. Estimation of cancer incidence and mortality risks attributed to diagnostic medical radiation exposure in Korea, 2013. J Korean Med Sci. 2018;33:e211. https://doi.org/10.3346/jkms.2018.33.e211.
27. Marant-Micallef C, Shield KD, Vignat J, Cléro E, Kesminiene A, Hill C, et al. The risk of cancer attributable to diagnostic medical radiation: Estimation for France in 2015. Int J Cancer. 2019;144:2954–63. https://doi.org/10.1002/ijc.32048.
28. Upton AC. National coluncil on radiation protection and measurements scientific COMMITTEE 1–6. The state of the art in the 1990's: NCRP report 136 on the scientific bases for linearity in the dose-response relationship for ionizing radiation. Health Phys. 2003;85:15–22.
29. Gomez BDB, Thierry-Chef M, Harbron I, Hauptmann R, Byrnes M, Bernier G. Risk of hematological malignancies from CT radiation exposure in children, adolescents and young adults. Nat Med. 2023;29:3111–9. https://doi.org/10.1038/s41591-023-02620-0.
30. Yang K, Ganguli S, DeLorenzo MC, Zheng H, Li X, Liu B. Procedure-specific CT dose and utilization factors for CT-guided interventional procedures. Radiology. 2018;289:150–7. https://doi.org/10.1148/radiol.2018172945.

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