Comparative Study of Diagnostic Accuracy between Office-Based Closed Needle Biopsy and Open Incisional Biopsy in Patients with Musculoskeletal Sarcomas

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Background: *The biopsy is a simple but critical step in the diagnosis of the musculoskeletal lesions. Although the open incisional biopsy traditionally has been considered the gold standard with high diagnostic accuracy, an alternative, the closed needle biopsy (CNB), has been developed and widely used as it can be performed at an outpatient clinic under local anesthesia or in combination with the image guidance. In the present study, the authors purpose to study the diagnostic accuracy of CNB without real-time image-guidance at an outpatient clinic by comparing it with open incisional biopsy in musculoskeletal sarcoma patients.*
Material and Method: *The authors retrospectively reviewed 200 biopsy cases of sarcoma patients since 2002-2011. There were 105 cases of open incisional biopsy 105 cases and 95 cases of CNB. The diagnostic accuracies of both mentioned methods were compared statistically in four aspects of histopathology: nature (benign or malignant), specific diagnosis, histological type and histological grade. The gold standard was a final pathological diagnosis of the resected specimens received from definite surgery correlated with clinical findings and imaging studies.*
Results: *The diagnostic accuracies of open incisional biopsy were 97.14% for nature, 89.52% for specific diagnosis, 89.52% for histological type, 88.57% for histological grade and the diagnostic accuracies of CNB were 96.84%, 89.47%, 88.42%, 86.32%, respectively. There was no significant statistical difference between the two methods in all histological aspects (p-value >0.05). The diagnostic yields of both methods were 98.13% for open incisional biopsy, 97.94% for CNB and there was no significant statistical difference (p-value >0.05). There were 6 cases (3%) for overall major errors, 3 cases (2.86%) from open incisional biopsy and 3 cases (3.16%) from CNB. There were 18 cases (9%) for minor errors, 9 cases (8.57%) from open incisional biopsy and 9 cases (9.47%) from CNB. There was no biopsy related complication in either method.*
Conclusion: *The office-based CNB diagnosis of musculoskeletal sarcoma can achieve an acceptably high diagnostic accuracy rate compared with open incisional biopsy.*

Keywords: *Close needle biopsy, Musculoskeletal sarcoma, Diagnostic accuracy*

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The biopsy is simple procedure but an important step in diagnostic processes of neoplasm, inflammatory, infectious, and reactive lesions of the musculoskeletal system. Although an open, incisional technique traditionally has been considered the gold standard, it requires an incision, operative room facilities, high cost and general or regional anesthesia. The overall diagnostic accuracy of open biopsy ranges from 91 to 96%[1-4]. Complications of open incisional biopsy reports include seroma, hematoma, infection, wound dehiscence with tumor fungation, local recurrence, and fracture[2-5]. An error from wrong incision placement may alter treatment options and negative outcomes in sarcoma patients. As an alternative to open biopsy, percutaneous techniques, such as closed needle biopsy (CNB) has been developed. These techniques can be performed as day surgery under local anesthesia at the outpatient clinic if the pertinent

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landmarks of the lesions were palpable or at the radiology suite using guided imaging: fluoroscopy, computed tomography (CT), magnetic resonance imaging (MRI), or ultrasound[6-17]. Advantages of CNB over open incisional biopsy include less invasive, smaller incisions, time-saving, no need of hospitalization, lower costs, avoidance of general or regional anesthesia, lower rate of wound complications; in addition, less obstacles of biopsy scar to definitive surgery, earlier commencement of chemotherapy or radiation, ability to perform in difficult, accessible locations (spine, pelvis), and easier to perform multiple-site biopsy at the same time. Potential disadvantages may include decreased diagnostic accuracy and tumor sampling errors. In the present study, the authors purposed to study the diagnostic accuracy of CNB without real-time image-guidance in an outpatient clinic setting comparing with standard open incisional biopsy in musculoskeletal sarcoma patients.

Material and Method

The present study was approved by our institutional research ethic board before starting; the informed consent was waived due to observational retrospective nature of the study. The authors retrospectively reviewed 200 patients from our single institution between January 2002 and December 2011. The data were collected from electronic-database of tumor registry of musculoskeletal oncology unit, Department of Orthopedics and Histopathological Reports from electronic-database of Department of Pathology. The inclusion criteria were musculoskeletal sarcoma patients with clinically pertinent mass (soft tissue sarcomas or bone sarcomas with soft-tissue extension), located in extremities or trunk. Such cases must have final pathological diagnosis of the masses excised from definite surgery as well as clinical and radiographic findings. The cases of CNB with imaged-guided technique (fluoroscopy, ultrasound, CT), unplanned excision, and recurrent sarcoma were excluded. The following data were collected:

1. Patient demographics: age, gender
2. Locations of tumor
3. Tissue origins: Bone sarcoma or soft tissue sarcoma
4. Provisional diagnosis obtained by CNB and open incisional biopsy, examined separately from 4 aspects: Nature (Benign & Malignant), Specific diagnosis (Name of tumor), Histological type, and Histological grade.
5. Numbers of biopsy in each method
6. Final pathological diagnosis of the resected specimen obtained by definite surgery combined with clinicoradiographic/laboratory or clinical course at follow-up period.
7. Majors error and minor errors
8. Biopsy related complications

All procedures of CNB and open incisional biopsy were performed by 5 orthopedic oncologists with fellowship training of the orthopedic oncology in the same hospital. All patients underwent the biopsy after completed investigations (laboratory, MRI, CT, Bone scan). The standard of biopsy procedures was similar and the principle of biopsy strict in all cases. The open incisional biopsy was performed in the operating theater under general, regional or local anesthesia depending on individual condition of patients. The patients usually stayed overnight in the hospital for postoperative for one day due to awareness of the acute complications. Regarding CNB, the needle devices were Tru-Cut® needles (14GX15cm, Allegiance, Illinois, USA) which were applied for all cases. After clinical examination, laboratory inspection, and radiographic imaging review, the risks/benefits and alternatives of biopsy were discussed with the patients and then formally consented to before any procedure. The authors performed the CNB in the procedure room in an outpatient clinic and discharged the patients in the same day. To perform the CNB, we prepared and draped the area in sterile technique followed by infiltration of 1% lidocaine for local anesthesia then a needle was advanced into the mass. The location of needle entry, depth and direction of needle was guided carefully by MRI of the lesion as the same principle of open incisional biopsy. The authors attempted to obtain multiple biopsy cores (at least 4 pieces) by single entry but coaxially[15]. The quality and amount of biopsy cores were inspected in each time. The core specimens were handled meticulously to avoid crushing artifacts on histopathological examination. The specimens were sent for bacterial culture or staining if infection were suspected. The wounds were closed by the compressive dressing to stop bleeding and the patients were observed for at least 30 minutes to ensure the absence of immediate complications, such as hemorrhage or neurovascular injury. All patients received the prescription for pain relief. The biopsy core specimens were fixed in formalin and routinely processed as hematoxylin and eosin staining for permanent sections of histopathology. Special stains and immunohistochemical studies were performed in selected cases to confirm the diagnosis. All cases were

examined and reported by experienced bone and soft tissue pathologists based on WHO classification of bone and soft-tissue tumors 2002[18]. The weekly pathological slide review had been performed by orthopedists and pathologists for case discussion and confirmation of the diagnosis. The monthly inter-department tumor conference by multidisciplinary musculoskeletal tumor specialist team (orthopedist, oncologist, pathologist, and radiologist) had been performed for review and discussion to confirm definitive diagnosis and plan for treatment in each case.

The authors evaluated the primary outcome, diagnostic accuracy and the secondary outcome (diagnostic yield, error, complication) by comparing both biopsy methods. Regarding diagnostic accuracy, we evaluated the diagnostic accuracy from 4 aspects of histopathology, namely, Nature (Benign & Malignant), Specific diagnosis (Name of tumor), Histological type, and Histological grade. Every sample had been evaluated and interpreted by following definitions. The correct result is the histopathology report compatible with final diagnosis which was obtained by histopathology reports of resected specimen while performing definite surgery compatible with final diagnosis, which correlated with clinicoradiographic/laboratory or clinical course. The incorrect result is the histopathology report from any biopsy incompatible with final diagnosis obtained by histopathology reports of resected specimen while performing definite surgery, inconclusive or requiring repeat biopsy. In addition, the diagnostic accuracy and diagnostic yield were calculated by outcome definition as follows: the diagnostic accuracy is defined as the sum of true positive and true negative results divided by the total number of biopsies performed. The diagnostic yield is number of effective biopsies (diagnostic result) dived by total numbers of biopsies. The errors (false positive & false negative) were divided into 2 types, major and minor errors. The major error means misdiagnosis in nature of tumor, such as diagnosing malignant tumor as benign tumor. The minor error means misdiagnosis in the specific name of sarcoma, histological type or histological grade. The biopsy related complications such as seroma, hematoma, infection, wound dehiscence with tumor fungation would be detected within 2 weeks after procedure.

Regarding statistical analysis, the descriptive statistics were used for demographic data, diagnostic accuracy and diagnostic yield. The Chi-square or Fisher's exact test was used to determine of association and compare proportions between two biopsy methods by STATA/MP12. All *p*-value are two-tailed. The *p*-value <0.05 was considered statistical significant.

Results

There were 200 cases included in the study, 105 cases from open incisional biopsy and 95 cases from CNB, male 109 cases (54.5%) and female 91 cases (45.5%). The mean age of the patients was 34.9±20 years, (30.8±18.9 years for open incisional biopsy and 39.4±20.3 years for CNB). There were 119 cases (59.5%) of bone sarcoma and 81 cases (41.5%) of soft-tissue sarcoma. The demographic data of patients and distribution of lesions are shown in Table 1 and 2. The final histopathogical diagnoses of lesions from both biopsy methods were shown in Table 3 and 4 which were the common bone and soft-tissue sarcomas in extremities and no different distribution. The diagnostic accuracies in each aspect comparing both methods were shown in Table 5. The diagnostic accuracies of open incisional biopsy were 97.14% for nature, 89.52% for specific diagnosis, 89.52% for histological type, 88.57% for histological grade and the diagnostic accuracies of CNB were 96.84% for nature, 89.47% for specific diagnosis, 88.42% for histological type, 86.32% for histological grade. There was no significant statistically different of both methods in all histological aspects (nature; *p*-value = 0.901 95% CI = -0.432 to 0.380, specific

Table 1. Demographic data of the patients

	Open incisional biopsy	Close needle biopsy
Gender		
Male	56 (53.3%)	53 (55.8%)
Female	49 (46.7%)	42 (44.2%)
Age (years)	30.8±18.9	39.4±20.3
Tissue origin		
Bone sarcoma	77 (73.3%)	42 (44.2%)
Soft-tissue sarcoma	28 (26.7%)	53 (55.8%)

Table 2. Distribution of the lesions (n = 200)

Location	Open incisional biopsy (%)	Close needle biopsy (%)
Neck	-	3 (3.2)
Shoulder	4 (3.8)	4 (4.2)
Arm	3 (2.9)	2 (2.1)
Elbow	1 (0.9)	-
Forearm	3 (2.9)	3 (3.2)
Wrist & hand	-	-
Back	5 (4.8)	4 (4.2)
Pelvis & hip	12 (11.4)	11 (11.6)
Thigh	16 (15.2)	28 (29.5)
Knee	49 (46.7)	29 (30.5)
Leg	11 (10.5)	9 (9.5)
Foot & ankle	1 (0.9)	2 (2.1)
Total	105	95

Table 3. Final pathological diagnosis for open incisional biopsy

Soft tissue sarcoma	
Malignant fibrous histiocytoma	8
Synovial sarcoma	7
Myxoid fibrosarcoma	3
Leiomyosarcoma	3
Epithelioid sarcoma	2
Fibrosarcoma	2
Liposarcoma	1
Malignant peripheral nerve sheath tumor	2
Bone sarcoma	
Osteosarcoma	55
Ewing's sarcoma	10
Chondrosarcoma	9
Chordoma	2
Adamantinoma	1
Total	105

Table 4. Final pathological diagnosis for close needle biopsy

Soft tissue sarcoma	
Malignant fibrous histiocytoma	15
Liposarcoma	9
Synovial sarcoma	8
Leiomyosarcoma	7
Myxoid fibrosarcoma	6
Epithelioid sarcoma	3
Rhabdomyosarcoma	3
Hemangiopericytoma	1
Malignant Peripheral nerve sheath tumor	1
Bone sarcoma	
Osteosarcoma	32
Chondrosarcoma	7
Ewing's sarcoma	3
Total	95

diagnosis; *p*-value = 0.991 95% CI = -0.227 to 0.224, histological type *p*-value = 0.803 95% CI = -0.250 to 0.193, and histological grade; *p*-value = 0.63 95% CI = -0.261 to 0.158). The diagnostic yields of both methods were 98.13% for open incisional biopsy, 97.94% for CNB. There was no significant statistically different between open incisional biopsy and CNB as shown in Table 6 (*p*-value = 0.919 95% CI = -0.469 to 0.520). There were 6 cases (3%) for overall major errors, 3 cases (2.86%) for open incisional biopsy and 3 cases (3.16%) for CNB. There were 18 cases (9%) for minor errors, 9 cases (8.57%) for open incisional biopsy and 9 cases (9.47%) for CNB. Major errors in CNB were misdiagnosis from malignant as benign namely; epithelioid sarcoma as fibromatosis, osteosarcoma as giant cell tumor and chondrosarcoma as chondroma. Although misdiagnosis, all cases were treated properly. Further open incisional biopsy was performed in one case which the other 2 cases were treated as sarcoma by wide local excision with or without chemotherapy. Since the authors make diagnosis of musculoskeletal tumor not only by a histological results but also multidisciplinary approach and clinic-radio-pathological diagnostic principle. So that clinical and radiological information must be compatible with pathology. Major errors in open incisional biopsy were misdiagnosis of fibrosarcoma as fibromatosis, epithelioid sarcoma as fibromatosis and osteosarcoma as giant cell tumor. Minor errors in CNB were misinterpreted in histological grade for 1 case, histological grade with histological type for 1 case, and histological grade with histological type and specific diagnosis for 7 cases. Minor errors

Table 5. Comparison of diagnostic accuracy of open incisional biopsy & close needle biopsy

Biopsy method	Accuracy rate %			
	Nature	Specific diagnosis	Histological type	Histological grade
Open incisional biopsy	97.14%	89.52%	89.52%	88.57%
Close needle biopsy	96.84%	89.47%	88.42%	86.32%
p-value	0.901	0.991	0.803	0.630
95% CI	-0.432 to 0.380	-0.227 to 0.224	-0.250 to 0.193	-0.261 to 0.158

Table 6. Comparison of diagnostic yield of open incisional biopsy & close needle biopsy

Biopsy method	Number of effective biopsies (diagnostic cases)	Total number of biopsies	Diagnostic yield (%)	*p*-value	95%CI
Open incisional biopsy	105	107	98.13%	0.919	- 0.469 to 0.520
Close needle biopsy	95	97	97.94%		

by open incisional biopsy were misdiagnosis in histological grade for 1 case, histological grade with histological type for 1 case, and histological grade with histological type and specific diagnosis for 7 cases. There was no complication in relation with both biopsy methods.

Discussion

The appropriate technique for biopsy in musculoskeletal sarcoma remains controversial and often selected by the preference of individual operating surgeons. Although the CNB has become more generally used in present, there are many studies that reported about diagnostic accuracy of CNB for musculoskeletal tumors with various techniques. They are namely conventional CNB without image-guided, with image-guided (fluoroscopy-guided, ultrasound-guided, CT-guided, MRI-guided,) or various devices with different core diameters. The overall diagnostic accuracy of CNB ranges from 68% to 100%[6-17,19-22]. Most of this literature includes the CNB with image-guided and are retrospective studies without comparative statistical analysis of 2 methods. Some studies exclude inadequate or non-diagnostic biopsies from their statistical analysis, which may falsely elevate accuracy rates[23-25]. Image-guided CNB yields higher diagnostic accuracy than CNB without real-time image-guided; this is logical because of direct, accurate targeting. However, the image-guided biopsy increases the time schedule, cost for procedure, risk of radiation exposure and requirement of radiological facilities. There are a few studies of CNB performing in office-based or outpatient clinic setting without image-guided and few reports, which compare diagnostic accuracy of 2 different biopsy methods. Skrzynski MC[2] reported diagnostic accuracy comparing outpatient core needle biopsy with open biopsy in musculoskeletal tumors. The study design was ambidirectional, prospective study in 62 patients with CNB compared with retrospective study in 50 patients with open incisional biopsy in the same institution. The diagnostic accuracy of CNB was 84% and the diagnostic accuracy of open incisional biopsy was 96%. The subjects included all musculoskeletal lesions, both benign and malignant. There was no comparison by statistic analysis and no subgroup analysis in histopathological aspects. Adams SC[6] reported the descriptive study of high diagnostic accuracy rate by the CNB at out-patient clinic setting without image-guided, however the subjects included all malignancy, both primary and secondary and has no comparison of the diagnostic accuracy with open incisional biopsy by statistic analysis. Thipachart[26] reported the prospective comparative study between CNB and open incisional biopsy in 52 patients. The diagnostic accuracy of CNB was 90.38% and open incisional biopsy was 98.37%. However, the patient subjects were included only in the soft tissue tumors, including both benign and malignant lesions compared between two methods in same patient simultaneously and performed in the operating room setting. They did

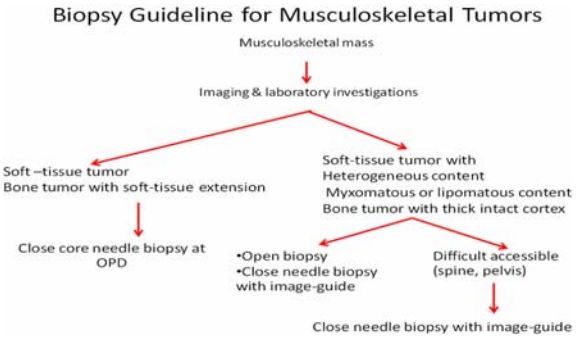

Fig. 1 Guideline for Biopsy in Musculoskeletal tumors.

not study in subgroup of other histological aspects.

The authors results of diagnostic accuracy of CNB are similarly high when compared with previous studies. In the subgroup analysis of 4 histological aspects, the diagnostic accuracy was reasonably reduced in subgroups, respectively, from nature, specific diagnosis, histological type and histological grade. This result compared favorably with the success rates for open incisional biopsy. It seems to be high diagnostic accuracy for CNB because we selected the subjects, which were only the sarcoma patients and did not include the other musculoskeletal lesions. The authors cautiously performed the biopsy on these patients based on clinical-radiological information. Our study has some limitations. First, it was a retrospective study, so the patients had been selected to perform any method without randomized allocation. The best way to study comparison of outcomes should be a prospective, randomized, controlled trial in which the only variable is the type of biopsy performed. Nevertheless, the both groups of patients were comparable because the same criteria were applied for inclusion in the present study. All patients had sarcomas with similar clinical presentation; both methods of biopsy were performed in a contemporary period by the same group of experienced orthopedic oncologists, at the same institution, and the same group of experienced bone and soft tissue pathologists reviewed the results. In addition, our subject was only the primary malignancy of bone and soft-tissue (sarcoma), benign, tumor-like lesion, infection, or metastases were not included. Thus, the diagnostic accuracy of our study did not represent the overall accuracy of musculoskeletal lesions. Furthermore, we performed the CNB in all patients only by one type instrument, Tru-Cut® needle, and unable to perform same number of specimens in every case. It seems to have high variability in the number of biopsy core specimens. However, we attempted to obtain at least the 4 core specimens for each biopsy in consideration of diagnostic yield[15] and all biopsy cases were performed by same group of orthopedic oncologists at the same institution. Therefore, our study could not represent the results from other needle types. Finally, the authors studied in the sarcoma treatment center with multidisciplinary team approach, many experienced specialists involved in every step of the treatment process from beginning including biopsy, so our results may not be generalized to other practices. Despite these limitations, this study provides important and clinically relevant information.

To initiate the treatment of musculoskeletal tumors, the correct diagnosis is important and the following crucial factors are required: adequate amounts of the sample, appropriate portion of the lesion and correct histopathological interpretation by experienced pathologist for definitive diagnosis. The errors of biopsy can occur depending on these factors sometimes. Some lesions in which the histological malignancy could not be determined was well-differentiated liposarcoma from benign lipoma or myxomatous tumor even by an open biopsy. Occasionally sarcoma has histological heterogeneity, the CNB is limited in amount of sample specimen, so most representative areas may be missed. Such situations may result in different diagnosis of provisional diagnosis by biopsy and definitive diagnosis of resected specimen. It recommends that meticulous examination of whole specimens be mandatory to make a final diagnosis. Multiple samples from different depths of the lesions under imaging information may minimize the risk of misdiagnosis in such cases. Besides the histopathological findings, our principle for musculoskeletal tumor diagnosis is a clinical and radiographic approach. Image findings obtained by radiographic procedures (plain radiographs, computed tomography, magnetic resonance imaging, etc) can provide useful information about the nature of the tumors. This approach is composed of multidisciplinary specialists' team, orthopedic oncologist, radiologist, and pathologist. The pathologist must be informed about this information to differential diagnosis before examining the tissue. Closed communication among the team is important to confirm the correct diagnosis of the musculoskeletal lesions. To achieve the cooperation of the specialists, the authors recommend performing the close needle biopsy at medical centers experienced in treatment of

musculoskeletal lesions. The authors did not specifically perform cost analysis of CNB in the present study; however, there are some reports about a savings of CNB versus open incisional biopsy[2,26] which we hypothesize in the present study in the same situation. In conclusion, the CNB, without real-time image guidance at outpatient clinic, can achieve an acceptable high diagnostic accuracy in diagnosis of musculoskeletal sarcomas compared with the open incisional biopsy. It is a reliable method for diagnosing musculoskeletal sarcoma. Nonetheless, a multidisciplinary team approach by clinic-radio-pathology diagnostic principle should be performed to diagnose musculoskeletal sarcoma cautiously. Our institute has been used this method in our clinical practice as shown in following strategic guidelines (Fig. 1).

Potential conflicts of interest

None.

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การศึกษาเปรียบเทียบความถูกต้องแม่นยำในการวินิจฉัยทางพยาธิวิทยาของมะเร็งชนิดปฐมภูมิ กระดูกและเนื้อเยื่อเกี่ยวพัน ระหว่างวิธีการเจาะตรวจแบบปิดและวิธีผ่าตัดแบบเปิด

พฤษพงศ์ ศรีสวัสดิ์, ภูวดล วีระพันธุ์, ทิพชาติ บุณยรัตพันธุ์, สุพิชัย เจริญวารีกุล, ทวี ทรงพัฒนาศิลป์, พิพัฒน์ ศรีธนาบุตร, สหชาติ พิพิธกุล

วัตถุประสงค์: เพื่อเปรียบเทียบความถูกต้องแม่นยำและความสามารถในการให้ผลวินิจฉัยทางพยาธิวิทยา, ความผิดพลาดและภาวะแทรกซ้อนในการวินิจฉัยทางพยาธิวิทยาของของมะเร็งชนิดปฐมภูมิของกระดูกและระบบเนื้อเยื่อเกี่ยวพันโดยเปรียบเทียบ 2 วิธี ระหว่างวิธีการเจาะตรวจแบบปิดที่ห้องตรวจโรคผู้ป่วยนอกและวิธีผ่าตัดแบบเปิดที่ห้องผ่าตัด

วัสดุและวิธีการ: การศึกษานี้เป็นรูปแบบการวิจัยเชิงพรรณาเปรียบเทียบในด้านการวินิจฉัยโรค โดยเก็บรวบรวมข้อมูลโดยการทบทวนย้อนหลังจากฐานข้อมูลเวชระเบียนผู้ป่วยและฐานข้อมูลทางพยาธิวิทยาเลือกประชากร ตัวอย่างผู้ป่วยมะเร็งชนิดปฐมภูมิกระดูกและระบบเนื้อเยื่อเกี่ยวพันที่มารับการรักษาระยะเวลา 10 ปีย้อนหลัง (พ.ศ. 2545-2554) โดยแบ่งประชากรตัวอย่างเป็น 2 กลุ่ม ได้แก่ กลุ่มมะเร็งปฐมภูมิที่วินิจฉัยโดยใช้วิธีการเจาะตรวจแบบปิด โดยที่ไม่มีเครื่องมือทางรังสีวินิจฉัยช่วยขณะทำหัตถการ ณ ห้องตรวจโรคผู้ป่วยนอกและกลุ่มมะเร็ง ปฐมภูมิที่วินิจฉัยโดยใช้วิธีการผ่าตัดแบบเปิดที่ห้องผ่าตัด นำมาเปรียบเทียบความแม่นยำในการวินิจฉัยทางพยาธิวิทยา โดยละเอียด 4 ด้าน ได้แก่ ธรรมชาติของก้อนเนื้องอก ชื่อโรคมะเร็งชนิดของโรคมะเร็ง ความรุนแรงของโรคมะเร็ง โดยใช้ผลพยาธิของก้อนโรคมะเร็งขณะทำการผ่าตัดรักษาตอนสุดท้ายเป็นมาตรฐานหลัก และยังทำการเก็บข้อมูลอื่น เปรียบเทียบด้วย ได้แก่ ความสามารถในการวินิจฉัยของแต่ละวิธี ความผิดพลาดที่เกิดจากการวินิจฉัย ภาวะแทรกซ้อนที่เกิดจากการทำหัตถการภายในระยะเวลา 2 สัปดาห์

ผลการศึกษา: จากผู้ป่วยมะเร็งปฐมภูมิของกระดูกและระบบเนื้อเยื่อเกี่ยวพันจำนวนทั้งสิ้น 200 ราย แบ่งเป็นจากกลุ่ม มะเร็งปฐมภูมิที่วินิจฉัยโดยใช้วิธีการผ่าตัดแบบเปิด 105 ราย กลุ่มมะเร็งปฐมภูมิที่วินิจฉัยโดยใช้วิธีการเจาะตรวจแบบปิด 95 ราย ความแม่นยำในการวินิจฉัยทางพยาธิวิทยาโดยวิธีการผ่าตัดแบบเปิด ได้แก่ 97.14% สำหรับธรรมชาติของก้อนเนื้องอก, 89.52% สำหรับชื่อโรคมะเร็ง, 89.52% สำหรับชนิดของโรคมะเร็ง, 88.57% สำหรับความรุนแรงของโรคมะเร็ง ความแม่นยำในการวินิจฉัยทางพยาธิวิทยาโดยวิธีการผ่าตัดแบบปิดได้แก่ 96.84%, 89.47%, 88.42%, 86.32% เรียงตามลำดับ เมื่อเปรียบเทียบโดยใช้วิธีทางสถิติพบว่าไม่มีความแตกต่างกันอย่างมีนัยสำคัญ อีกทั้งไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติสำหรับความสามารถในการวินิจฉัยของแต่ละวิธี 98.13% โดยวิธีการผ่าตัดแบบเปิด, 97.94% โดยวิธีการเจาะตรวจแบบปิดพบว่ามีความผิดพลาดรุนแรงทั้งหมดที่เกิดจากการวินิจฉัยจำนวน 6 ราย (3%), 3 ราย (2.86%) โดยวิธีการผ่าตัดแบบเปิดและ 3 ราย (3.16%) โดยวิธีการผ่าตัดแบบปิดพบว่ามีความผิดพลาดเล็กน้อยทั้งหมด 18 ราย (9%), 9 ราย (8.57%) โดยวิธีการผ่าตัดแบบเปิด 9 ราย (9.47%) โดยวิธีการเจาะตรวจแบบปิดไม่มีภาวะแทรกซ้อนที่เกิดจากตรวจวินิจฉัยทั้งสองวิธี

สรุป: ความถูกต้องแม่นยำและความสามารถในการให้ผลวินิจฉัยทางพยาธิวิทยาโดยวิธีการเจาะตรวจแบบปิด โดยที่ไม่มีเครื่องมือทางรังสีวินิจฉัยช่วยขณะทำหัตถการ ณ ห้องตรวจโรคผู้ป่วยนอกให้ผลที่ไม่แตกต่างกับวิธีการผ่าตัดแบบเปิดที่ห้องผ่าตัดในผู้ป่วยมะเร็งปฐมภูมิของกระดูกและระบบเนื้อเยื่อเกี่ยวพัน