

Comparison of Bone Marrow Biopsy Specimens Obtained Using a Motorized Device and Manual Biopsy Systems

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ABSTRACT

Objective: Bone marrow biopsy is an essential component in the diagnosis of hematopoietic disorders. Researchers evaluated the quality of bone marrow biopsy tissue acquired with a motorized bone marrow biopsy device versus a standard manual device based on the following criteria: biopsy length, percentage of aspiration artifact/intraströmral hemorrhage, length of nonhematopoietic bone, and overall quality of the sample. **Methods:** Bone marrow biopsies (motorized, $n = 30$; manual, $n = 120$) from two academic medical centers were evaluated by two board-certified hematopathologists. For each specimen, the following parameters were recorded: biopsy length (cm), aspiration artifact (assessed in intervals of $\leq 10\%$, $11\%–25\%$, $26\%–50\%$, $51\%–75\%$, and $>75\%$), length (cm) of nonhematopoietic biopsy (e.g., cortical bone and skin), and overall quality of sample (inadequate, suboptimal, adequate, and excellent). **Results:** Operators from two centers included physicians and nurse practitioners. The manual system

was superior to the powered drill with respect to the amount of crush artifact ($0.15 \text{ cm} \pm 0.01$ vs. $0.24 \text{ cm} \pm 0.04$, $P = 0.01$ [t-test]). There was a trend toward less aspiration artifact/intraströmral hemorrhage with the use of the manual biopsy; however, the difference was not statistically significant ($P = 0.06$). There was no statistically significant difference in the overall biopsy size, biopsy length, amount of nonhematopoietic elements, and overall adequacy of the sample. **Conclusions:** There was no significant difference in the biopsy length, amount of nonhematopoietic elements, and overall adequacy of the sample. Results suggest that the manual bone marrow biopsy device has significantly less crush artifact of the specimen and has a trend toward less aspiration artifact/intraströmral hemorrhage as well.

Key words: Bone marrow aspiration and biopsy, crush artifact, manual approach, motorized device, pathology, quality

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Introduction

Bone marrow biopsy is an integral part of the diagnosis, staging, and treatment management in patients with hematopoietic and nonhematopoietic disorders.^[1] It has been established that the quality of the biopsy has a role in the ability of pathologists to histologically identify and correctly diagnose a disease.^[2] Biopsy provides overall cellularity and information about detection of focal lesions, marrow cellularity, tumor metastasis, and the detection of disease.^[3,4]

In particular, the length of the biopsy (a surrogate marker of quality) has been recommended to be at least 20 mm in the assessment of staging and response in non-Hodgkin's lymphoma patients.^[5] However, the biopsy length is often suboptimal due to various factors such as operator experience and patients' tolerance of the procedure.^[6] In hopes of improving the quality of bone marrow specimens obtained, researchers evaluated the use of the motorized biopsy device.

The motorized biopsy device is a battery-powered drill used to perform bone marrow aspiration and biopsy procedures. The device is designed to improve the overall experience by decreasing procedure time, reducing pain associated with the procedure, and decreasing physical effort required by clinicians as compared to a manual approach. A previous pilot study evaluating the motorized device resulted in overall positive feedback from the participants in all areas assessed, namely patient satisfaction, decreased pain, provider satisfaction, quality of specimen, and number of complications.^[7] Additional studies also report decrease in pain with the use of a motorized device.^[8,9]

The greater the length, width, and volume of the core biopsy specimen, the greater the accuracy of diagnosis will be made.^[10] Overall, quality of aspirate specimen can be affected by hemodilution and the presence of crush artifact and hemorrhage in the sample.^[8] The evaluation of marrow is imperative in discerning the efficacy of treatment and providing information on the current disease status. If a diagnosis cannot be made due to the poor quality of a specimen, the procedure will most likely need to be repeated until an accurate diagnosis can be obtained.^[10]

Several prospective, randomized controlled trials have previously been reported showing that biopsy lengths obtained by the drill have been longer.^[6,3,8,10] Few other studies have been completed with thorough end points, other than length, detailing results on specimen quality. One study revealed similar biopsy quality between manual and motorized devices with the presence of crush artifact, while another did not indicate a presence of crush artifact.^[11,12] Similarly, in the pilot study, an increased amount of focal intrastromal hemorrhage was identified, prompting a need for further investigation.^[7]

Although many studies show an increased specimen size with the use of a motorized device, there is little evidence showing the overall quality of the sample when comparing a motorized device with the manual method. The goal of this study was to retrospectively evaluate the bone marrow biopsies and assess the quality of the samples based on biopsy length, amount of nonhematopoietic elements, crush artifact, and aspiration artifact/intrastromal hemorrhage.

Methods

Research setting and population

The study received ethical clearance and permission from the university and hospital's Institutional Review Board and was in compliance with all ethical standards set by the committee. Each individual participated voluntarily; informed consent was obtained. Bone marrow biopsies (motorized, $n = 30$; manual, $n = 120$) were obtained and analyzed at an academic medical center. Inclusion criteria for both groups were patients who needed a bone marrow aspiration and biopsy as noted in the physician order. Both groups excluded patients with multiple myeloma.

Research instrument

The motorized device used was a battery-powered biopsy drill (11G \times 103 mm). The manual device used was a 2-needle technique involving the T-Lok™ Bone Marrow Biopsy Needle (11G \times 4") and the Argon Bone Marrow Aspiration Needle (15G \times 4"). For both approaches, lidocaine (Xylocaine-MPF) was injected locally, as conscious sedation is not utilized in this setting. Each participant started with 50 mg/5 mL of 1% solution. The average amount of lidocaine used was 5–10 ccs with the maximum amount of 30 ccs used.

Procedure

For the manual approach, physicians and nurse practitioners performed the 2-needle procedure. The practitioner applied Xylocaine-MPF and used a small surgical blade to make a skin incision to insert the bone marrow aspiration needle. Once the needle contacted the bone, it was advanced by slow manual rotation until penetrating the cortical bone and entering the marrow cavity. A syringe collected a small amount of bone marrow aspiration.

For the motorized approach, a trained nurse practitioner followed the manufacturer directions for use of the motorized device. The same amount of Xylocaine-MPF was used with a manual procedure. The motorized device utilizes a cannula design (11G needle) to capture and hold bone marrow specimen from the soft-bone tissue. When using the motorized device, the procedure is completed by

withdrawing marrow from the same anatomical location, the iliac crest. The procedure was performed in accordance with device directions for use, resulting in retrieving bone marrow aspiration to be analyzed by pathology.

Data collection and analysis

Two nurse practitioners obtained all of the motorized device specimens, while the manual specimens had been obtained previously by physicians, fellows, and nurse practitioners. Two board-certified hematopathologists evaluated the biopsies. For each specimen, researchers developed a two-page comprehensive evaluation tool [Table 1] and the following end points were assessed and recorded: biopsy length (cm), aspiration artifact (assessed in intervals of ≤10%, 11%–25%, 26%–50%, 51%–75%,

and >75%), length (cm) of nonhematopoietic biopsy (e.g., cortical bone and skin), and overall quality of sample (inadequate, suboptimal, adequate, and excellent).

Two board-certified hematopathologists came to a consensus on judging the end points using a multiheaded microscope. All specimens retrieved by the motorized device were evaluated immediately upon biopsy. The specimens retrieved by manual technique were retrospectively selected and evaluated to serve as the comparison group.

Results

Researchers entered the data into Excel and manually calculated the demographic results and *P* values. The determined descriptive statistics for each demographic variable are summarized in Table 2. *P* < 0.05 was considered statistically significant.

The power drill showed a slight increase, yet no statistical significance, in the size of biopsy specimen over the manual procedure [(1.23 ± 0.09) cm vs. (1.09 ± 0.04) cm, *P* = 0.33]. Overall, there were less nonhematopoietic elements present in the power drill specimens compared to the manual procedure, but there was no statistical significance [(0.15 ± 0.03) cm vs. (0.20 ± 0.02) cm]. Table 3 summarizes the diagnostic adequacy ratings.

Data indicate a statistically significant increase in the average amount of crush artifact present in the power drill specimens versus manual [(0.22 ± 0.04) cm vs. (0.15 ± 0.01) cm, *t*-test of *P* = 0.01]. This study revealed no statistically significant difference between the manual biopsy procedure and powered drill, in respect to biopsy size, aspiration artifact, intrastromal hemorrhage, amount of nonhematopoietic elements, or overall quality of specimen. However, the study results indicate a statistically significant difference in crush artifact, with a decreased amount in the manual procedure, thus indicating the manual method to be more superior when measuring crush artifact.

Discussion

There was no significant difference in the biopsy length, amount of nonhematopoietic elements, and overall adequacy of the sample. Results of this trial suggest that the manual bone marrow biopsy device has significantly less crush artifact and shows a trend toward less aspiration artifact/intrastromal hemorrhage as well. Given the results, the motorized bone marrow biopsy device produced samples that were not significantly different from samples retrieved via the manual method.

These findings were not consistent with past research with regard to significantly larger sample sizes.^[6,8,13,14] In addition, some past studies found the manual technique to produce on an average more evaluable marrow specimens;^[14] however,

Table 1: Sample biopsy analysis chart	
Pathology trephine biopsy review (completed by pathologist)	
Trephine biopsy	
Trephine size (cm×cm): _____	
Aspiration artifact/intrastromal hemorrhage: _____	
a. 0%-20%	
b. 21%-50%	
c. >50%	
Cortical/subcortical bone size: _____	
a. <2 mm	
b. Other: _____mm	
Crush artifact: _____	
a. Absent	
b. 0-2 mm	
c. Significant: _____mm	
Diagnostic quality: _____	
a. Poor/suboptimal/inadequate	
b. Good/adequate	
c. Excellent	
Aspirate	
Spicules: _____	
a. Absent	
b. Present, few	
c. Present, many	
Diagnostic quality: _____	
a. Poor/suboptimal/inadequate	
b. Good/adequate	
c. Excellent	
Dry tap: _____	
a. Yes	
b. No	
Touch preps prepared: _____	
a. Yes	
b. No	
Touch prep quality: _____	
a. Poor/suboptimal/inadequate	
b. Good/adequate	
c. Excellent	
Additional comments:	
Adapted from tool; to use with author's permission (cglennon@kumc.edu)	

Table 2: Demographic data

Age/Diagnosis	Manual (n = 120)	Powered (n = 30)
Age (median, range)	62, 15-91	65, 36-84
Diagnosis		
Metastasis	4	0
Hodgkin lymphoma	2	0
MDS	14	6
CML	4	0
Pvera	1	1
CLL	6	1
Acute leukemia	27	5
NHL	22	7
CMML	2	1
Primary myelofibrosis	1	1
ALL	2	1
Other	35	7

MDS: Myelodysplastic syndromes, CML: Chronic myeloid leukemia, Pvera: Polycythemia vera, CLL: Chronic lymphocytic leukemia, NHL: Non-Hodgkin's lymphoma, CMML: Chronic myelomonocytic leukemia, ALL: Acute lymphoblastic leukemia

Table 3: Adequacy of specimen

Diagnostic quality	Manual (%)	Powered (%)
Inadequate	2.5	0
Suboptimal	10.8	20.0
Adequate	65.8	60.0
Excellent	20.8	20.0

this study found the two techniques to be very comparable. Comparable samples are in line with one other researcher's findings, which also identified crush artifact in the motorized device specimens.^[11] This specific motor device's high-powered speed paired with the internal thread, located in the needle, has potential to damage and decrease the overall specimen size. These high-powered speeds create ease for the operator but present a potential danger for neighboring tissues if the needle were to slip off the bone.^[15]

Examination of marrow is essential for determining the stage of cancer and appropriate treatment for those who are newly diagnosed, as well as those undergoing treatment, with hematopoietic and nonhematopoietic diseases. Procedures and devices that yield quality specimens are of the utmost importance. Advanced practice nurses may perform bone marrow procedures; therefore, the use of a motorized device is a viable option. Previous studies indicate provider satisfaction with the motorized device and the time required to perform the procedure with decreased pain level reports from patients.^[7-9] When evaluating tools and techniques to use for bone marrow aspiration and biopsy, the use of a motorized device can be considered.

The small sample size within the motorized device group can be viewed as a limitation due to an inability to generalize the results. In addition, the number of practitioners completing the procedures presents another limitation.

Even though all practitioners received the same training and instructions on how to complete the procedures, it cannot be assumed that there is no variation among technique, pressure, speed, etc., thus an interoperator variation can be considered as a limitation. Strengths include the large sample size within the group receiving the manual approach. In addition, the variety of end points assessed for each specimen make this study robust in the investigation of the quality of specimens retrieved.

Further research is needed to determine if the use of a motorized device increases the quality of bone marrow aspiration and biopsy specimens. Research involving a greater number of patients would be beneficial to analyze the quality of each specimen compared to the manual approach and ensure statistical relevance. It is also important to look at patient and clinician preferences, cost efficacy, time efficiency, and, most importantly, the accuracy of results when determining which approach is best. For clinicians, such as advanced practice nurses, who do multiple bone marrow procedures per day, use of the drill to decrease risks of potential injury from repetitive motion associated with the manual device, should be reviewed. Many previous studies have looked at pain and anxiety related to bone marrow aspirations.^[16-20] Further research can be completed to compare pain and anxiety levels using the motorized bone marrow biopsy device versus manual approach. In order to determine the superior procedural approach, all variables contributing to patient and clinician experience should be considered for future research implications.

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Conflicts of interest

There are no conflicts of interest.

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