

Minimally Invasive Ultrasound-guided Synovial Biopsy Using SuperCore Biopsy Instrument

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Abstract

Background: To develop a new method for synovial biopsy with ultrasound (US) guidance and a semi-automatic SuperCore biopsy instrument.

Materials and Methods: Twenty-two patients (8 men and 14 women, median age 57 years (range 22–79 years)) with active arthritis or tenosynovitis were enrolled from April 2012 through October 2012. Each patient had one joint or tendon biopsied. US examination was performed to determine the optimal synovial site for biopsy. After skin disinfection and local anaesthesia, a portal was established using a trephine needle as needed. An 18-gauge SuperCore biopsy needle was placed into the target synovial site via the portal or just percutaneously under US guidance with free hand technique. Repeated needle passes and cuts to obtain 3-10 pieces of synovial tissues in each joint. The success of biopsy was defined as identification of synovium on histological examination.

Results: Synovium of 21 joints (10 knees, 6 wrists, 3 ankles, 1 elbow and 1 metacarpophalangeal joint) were biopsied. One patient had biopsy of flexor digitorum tendon sheath. All biopsies obtained adequate amounts of synovial tissues for histologic reading with a success rate of 100%. Synovial lining was identified in 18 (85.7%) of 21 joints. The patient with flexor digitorum tenosynovitis was proven to have mycobacterial infection by histological examination. All patients tolerated the procedures well, and no complication was observed during 2-week follow up.

Conclusions: US-guided synovial biopsy using SuperCore biopsy instrument is a promising method for synovial research. It has the advantages of simple, mini-invasiveness and high success rate. The complication is rare.

Keywords: Arthritis, Tenosynovitis; Mycobacterium; Synovial biopsy; Ultrasound guidance

Introduction

Synovial hypertrophy and synovitis are the main characteristics of inflammatory arthritis. Synovium is usually the area where disease pathogenesis take place, for example, in cases of rheumatoid arthritis (RA). Thus synovial histology provides diagnostic clues and aids in assessment of disease activity and therapeutic response [1].

In gout and pseudogout, crystal deposition in synovium appears as punctiform hyperechoic spots, namely bright stippled foci, on ultrasound (US) image [2]. In infectious arthritis, microscopic examination of synovium may be valuable in detection of causal pathogens, especially for mycobacteria, fungi and varicella-zoster virus. Synovial histology also provides diagnostic clues for sarcoidosis, amyloidosis and hemochromatosis [1].

However, current synovial biopsy methods such as arthroscopy and blind needle biopsy are not optimal due to complex procedure and higher cost in the former and sampling error in the latter [3].

Ultrasonography has been used for assessing both synovium and tendon lesions in patients with joint pain and/or swelling [4]. US could be applied for guiding needle aspiration and injection [5].

US-guided synovial biopsy has been proposed as a feasible method for obtaining synovial samples [6-8]. The instruments used in the former US-guided synovial biopsies are Tru-cut needles [6,7] or “portal and forceps” [8]. Here we report our experience of an alternative method for synovial biopsy method under US guidance using a semi-automatic SuperCore biopsy instrument.

Materials and Methods

This study was approved by our Institutional Review Board. Twenty-two patients (8 men and 14 women) with active arthritis or tenosynovitis were enrolled from April 2012 through October 2012. The patients' median age was 57 years (range 22–79 years). Sixteen (72.7%) of them were outpatients and the remainders were inpatients.

The pre-biopsy clinical diagnoses included RA (n = 11), septic arthritis (n = 4), systemic lupus erythematosus (SLE, n = 2), adult-onset Still's disease (AOSD, n = 1), idiopathic arthritis (n = 3) and

hand flexor tenosynovitis (n=1). The patients with RA, SLE, AOSD and idiopathic arthritis were oligo- or polyarthritis while the patients with septic arthritis were mono arthritic.

The median disease duration was 12 months (range 0.25-120 months). The diagnosis of RA was made based on the 2010 American College of Rheumatology (ACR)/European League Against Rheumatism criteria for the classification of RA [9]. The diagnosis of AOSD was made based on the classification criteria proposed by Yamaguchi in 1992 [10]. The diagnosis of SLE was made based on the 1997 ACR revised criteria for the classification of SLE [11]. The indications of synovial biopsy in the patients with RA, SLE and AOSD were assessing disease activity and excluding the possibility of concomitant joint infection and amyloidosis.

The indication of synovial biopsy in the patients with septic arthritis was identifying the causal pathogens because the initial synovial fluid cultures failed to yield pathogens. In the patients with idiopathic arthritis and tenosynovitis, synovial biopsies were performed for diagnosis. Each patient had one joint or tendon biopsied. The contraindications were skin infection, bleeding tendency, xylocaine allergy and uncooperative patients.

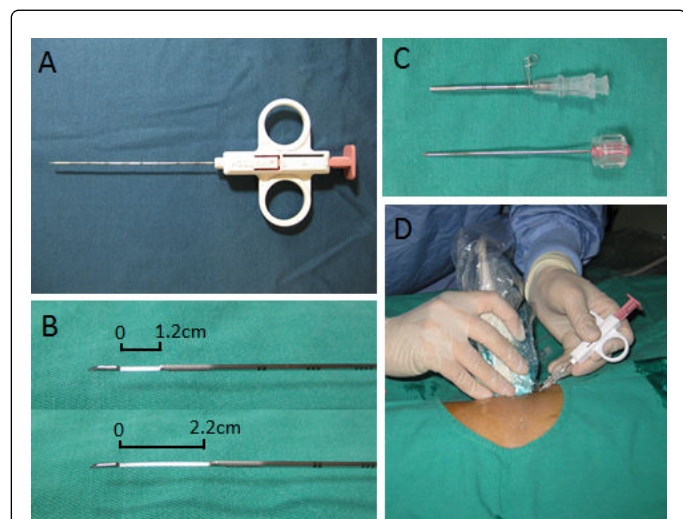


Figure 1: SuperCore biopsy instrument.

(A) A semi-automatic biopsy needle with 18-gauge diameter and 9-cm length. (B) The specimen notch (1.2cm or 2.2cm) is exposed when the sonographer advance the stylet. (C) A 17-gauge trephine needle (upper) with matching stylet (lower) is used to establish a portal. (D) Biopsy of knee synovium via a portal under ultrasound guidance with free hand technique.

The ultrasonic assessments of joints and the US-guided synovial biopsies were performed with a General Electric LOGIC 500 unit (GE, Milwaukee, Wisconsin, USA) using a 6-13 MHz linear array transducer. The ultrasonic assessments of joints were performed before synovial biopsies in order to determine the optimal areas of synovium for histologic reading.

In principle, the most hypertrophied area of synovium was the target for biopsy. The scanning techniques used during performing biopsies were dorsal longitudinal approach in metacarpophalangeal (MCP) joint, elbow and ankle, dorsal longitudinal or transverse approach in wrist, and longitudinal lateral or suprapatellar transverse

approach in knee. The probe position was longitudinal while performing tendon sheath biopsy.

All biopsies were performed by the author (Lai K-L) who had an eight-year US experience. A trained nurse or technician was required for assistance. The operator wore sterile gloves and a mask. The US probe was covered with a sterile plastic sleeve. No sedation was used. Skin disinfection was performed with tincture iodine and 70% alcohol.

A sterile cloth with a hole was placed on the area interested. Sterile gel was applied to the skin. Local anesthesia with 1 to 10 ml of 2% xylocaine that was injected into the involved skin, subcutaneous tissue and joint cavity or tendon sheath without air bubbles in the syringe to avoid US artifacts. A portal was established using a trephine needle (Medical Device Technologies, inc., USA) under US guidance in patients who needed repetitive needle passes to obtain more than 3 specimens.

An 18-gauge semi-automatic SuperCore biopsy instrument (Medical Device Technologies, inc., USA), with needle length of 9 cm, was used to obtain synovial tissues via the portal (or directly percutaneous puncture if no portal was established) under US guidance with free hand technique (Figure 1).

The operating skills of this instrument followed the manufactory's instructions. Repeating needle passes and cuts to obtain 3-10 pieces of synovial tissues in each joint (Figures 2 and 3) and, in the case of tenosynovitis, 3 pieces of tendon sheath (Figure 4).

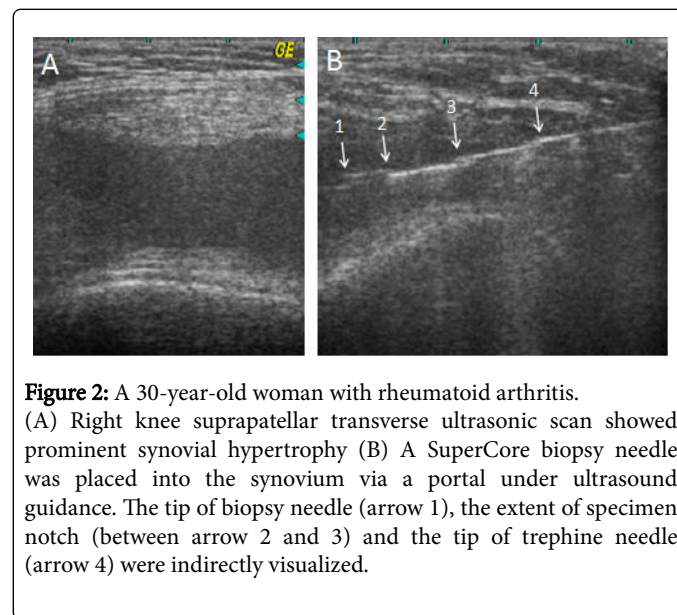


Figure 2: A 30-year-old woman with rheumatoid arthritis. (A) Right knee suprapatellar transverse ultrasonic scan showed prominent synovial hypertrophy (B) A SuperCore biopsy needle was placed into the synovium via a portal under ultrasound guidance. The tip of biopsy needle (arrow 1), the extent of specimen notch (between arrow 2 and 3) and the tip of trephine needle (arrow 4) were indirectly visualized.

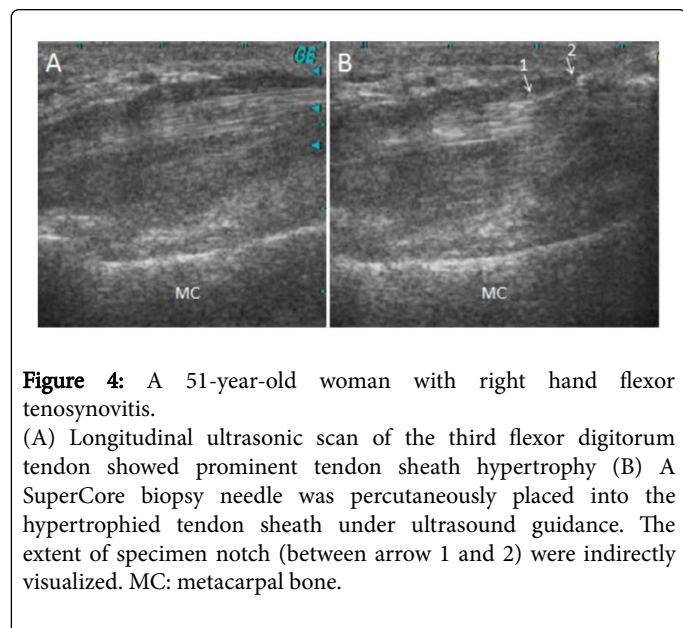
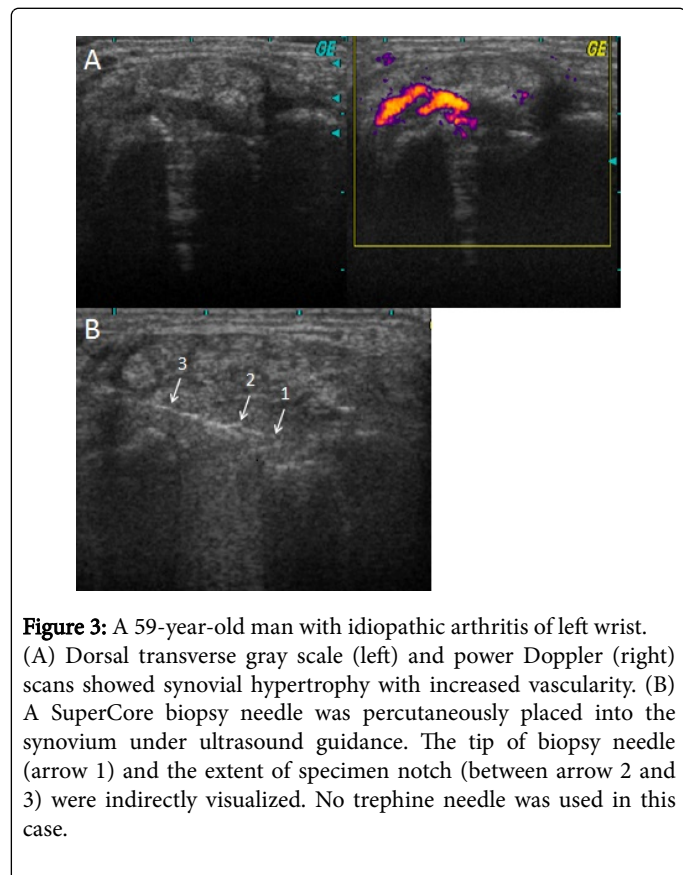
The optimal amount of synovial specimens was determined by both the kinds of synovial research and the joint size. After biopsy, the puncture site was compressed with sterile gauze and elastic band, and kept dry until next day.

Patients were asked to immobilize the joint within the initial 2 hours and avoid heavy physical activities with the involved joint for 3 days. All patients were followed for 2 weeks to observe any possible complication such as skin and joint infection, hematoma and deep vein thrombosis.

The biopsied specimens were immediately fixed in 4% formaldehyde for up to 24 hours and embedded in paraffin. Tissue sections were

stained with haematoxylin and eosin and assessed by the same histopathologist.

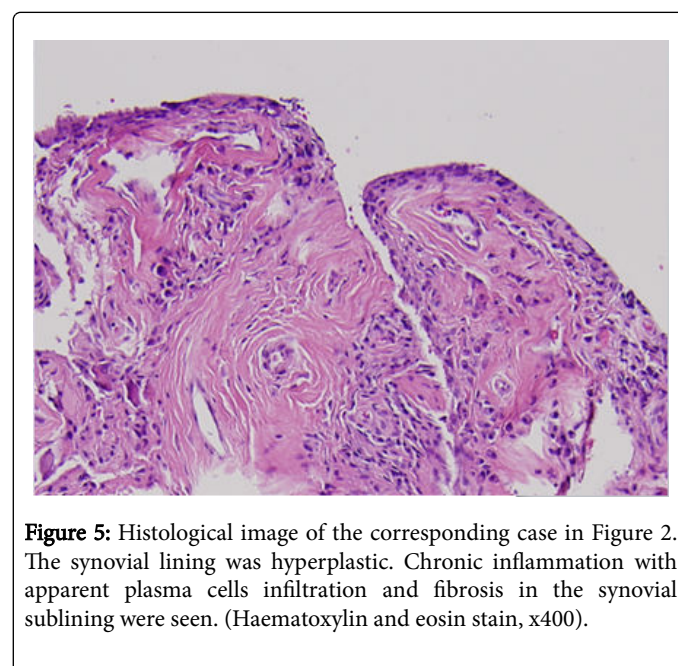
The biopsy procedure was rated as successful if synovial tissue was identified on histological examination. Besides, the lining layer of synovium was checked. We also evaluated the feasibility of obtainment of synovial lining using this biopsy method by calculating the ratio of synovial lining-positive joints to total biopsied joints.



Results

Synovium of 21 joints including knee (n = 10), wrist (n = 6), ankle (n = 3), elbow (n = 1) and MCP joint (n = 1) were biopsied. One patient had biopsy of tendon sheath of hand flexor digitorum tendon. MCP joint was the smallest joint biopsied in our study.

For repetitive needle passes and cuts, a portal was established respectively in 9 patients who received knee biopsies. The length of specimen notch of the stylet was set at 1.2 cm for all joints, and the length of the obtained specimens ranged from 1 mm to 8 mm. All synovial biopsies obtained adequate amount of specimens for histologic reading with a success rate of 100% (Figure 5).



Synovial linings were identified in the specimens from 18 joints with an availability of 85.7%. In the patient with flexor digitorum tenosynovitis, the histological examination of tendon sheath specimens revealed granulomatous inflammation with acid-fast bacilli that was consistent with mycobacterial infection (Figure 6).

We took 25-40 minutes to complete a synovial biopsy procedure per case. All patients tolerated the biopsy procedures well and did not feel pain due to filling of xylocaine in joint cavity or tendon sheath.

The blood loss during biopsy procedure was minimal (less than one gauze). No procedure-related complication such as skin and joint infection, hematoma and deep vein thrombosis was observed during 2-week follow period.

We had encountered some technical difficulties in this study. Because the US beam is two dimensional and narrow, we were difficult to visualize the needle by US imaging with free hand technique in the first cases.

While we had practiced more, the needle position could be easily indirectly visualized in the later cases. The accuracy of needle positioning using free hand technique was operator-dependent and would be improved by practice and practice. Besides, the ability to indirect visualization of the needle was decreased when the needle direction was more parallel to the US beam and when the depth of needle position increased.

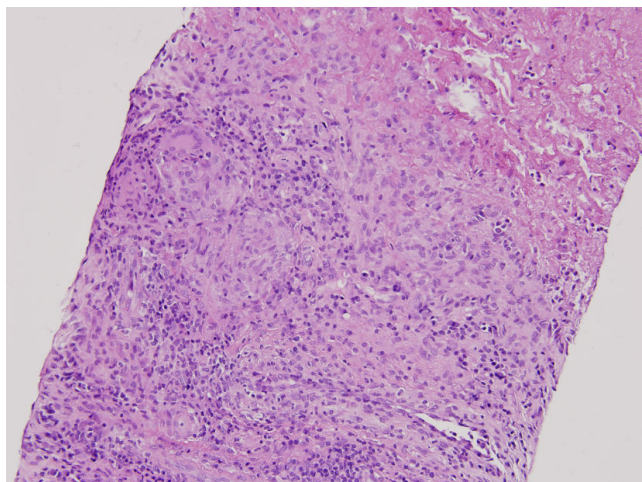


Figure 6: Histological image of the corresponding case in Figure 4. Granulomatous inflammation with acid-fast bacilli in the tendon sheath supported the diagnosis of mycobacterial infection. (Haematoxylin and eosin stain, x400).

Discussion

Histological analysis of synovial biopsies may provide diagnostic clues for idiopathic arthritis, and is valuable in early diagnosis of RA [1]. Some studies have documented the role of synovial pathologies in assessment of disease activity and prediction of response to biologics in RA [12-14]. There are three methods proposed for synovial biopsy. The first is blind needle technique using a simplified biopsy needle designed by Parker and Pearson in 1963 [15]. The second is arthroscopy, and the third is US-guided biopsy using Tru-cut needle [6,7] or portal and forceps [8]. The major disadvantage of blind needle technique is sampling error. Synovial sites adjacent to cartilage cannot be easily biopsied by a blind procedure [1]. Usually the application of blind needle technique is limited to knee joint. Arthroscopy remains the gold standard method for synovial biopsy. It has the advantage of direct visualization of synovium and could harvest large amount of synovial tissues. The disadvantages of arthroscopy include higher costs and the need for two portals into a joint [1]. Arthroscopy has been mostly applied to the knee joint.

As more and more rheumatologists used musculoskeletal US for management of arthritis in the past decade, US-guided interventional procedures have been developed in order to perform accurate aspiration and injection. New methods of synovial biopsy with US guidance also have been developed. US-guided synovial biopsy using a 18-gauge diameter Tru-cut needle equipped with an automated gun had been proposed by van Vugt RM et al. [6] with a success rate of 100% in seven wrist joints while no complication was encountered. In 2006 Marin F et al. [8] reported their experience in US-guided synovial biopsy using Tru-cut needle in 83 patients with monoarthritis of unknown etiology. Synovial tissues were obtained in 78 patients (successful rate 94%) from several joint sites including shoulder, elbow, wrist, hip, knee and ankle. No procedure-related complication occurred [7].

Koski JM and Helle M [7] reported the utility of US-guided synovial biopsy using portal and forceps, a set of device borrowed from

angiology and gastroenterology, in 37 outpatients with mono or polyarthritis [8]. Biopsy samples were taken from small and large joints, bursae, and tendon sheaths. Representative synovial tissue in adequate amounts for histopathological evaluation was obtained in 33/37 cases (successful rate 89%). The biopsy procedures were well tolerated, but one complication of skin infection was encountered [8].

In this study we use a semi-automatic SuperCore biopsy instrument for synovial sampling. It is a variant of Tru-cut needle and has been clinically used for biopsies of liver, breast tumor and pleura in Taiwan, but to our best knowledge, has not been reported for biopsy of synovium yet. Thus we tried to evaluate the utility of SuperCore biopsy instrument with US guidance in synovial biopsy. The manufactory provides SuperCore biopsy needles with varied diameter (14~20 gauge) and length (9 or 15 cm). Our experience shows that an 18-gauge diameter 9-cm length needle is suitable for most joint sites, from the small joint-MCP joint to the large joint-knee. An exclusive trephine needle is commercially available from the manufactory. We establish a portal using a trephine needle in order to repeat biopsies if more than 3 pieces of synovial tissues are required. Our study demonstrates that US-guided synovial biopsy using SuperCore biopsy instrument has a success rate of 100% in 22 patients with active arthritis or tenosynovitis. It also has a high success rate (85.7%) in obtaining synovial lining which is an important target for RA research. It is feasible to identify mycobacterial infection of soft tissues using US-guided needle biopsy. No procedure-related complication is encountered.

The SuperCore biopsy needle has some advantages on synovial biopsy. It is easier to approach deep synovial areas adjacent to bone or cartilage where rheumatoid pannus often present. When the sonographer moves plunger to advance stylet exposing specimen notch, the target synovial lesion locating at the specimen notch could be indirectly visualized. The lining layer of synovium, an important synovial site for molecule biologic study of RA, also can be obtained using this biopsy technique. The SuperCore biopsy needle is a semi-automatic device, so the sonographer can hold US probe with one hand and operate the needle with another hand simultaneously. The needle is disposable, so there is no risk of transmission of infectious disease. US-guided synovial biopsy using SuperCore biopsy instrument is a simple and safe procedure with minimal invasiveness. The puncture wound is minimal. It can be served in outpatients and is well tolerated by patients. It is applicable to both small and large joints as well as to tendon sheath.

This study may have some limitations. First, the utility of US-guided synovial biopsy using SuperCore biopsy instrument in larger joint-hip and shoulder-are not clarified in this study although it is theoretically applicable. Further study is needed to clarify its utility in hip and shoulder. Second, this biopsy needle may not be applicable to smaller joint-proximal interphalangeal joint because the specimen notch is relatively too long. Third, this technique may not work well in biopsy of unhyertrophic synovium.

In conclusion, US-guided synovial biopsy using a semi-automatic SuperCore biopsy instrument is a promising method for synovial research. It has the advantages of simple, mini-invasiveness and high success rate. The complication is rare. We hope that this simplified synovial biopsy method could be widely used in turn to promote synovial researches, to discover pathogenesis of early RA, to predict therapeutic response to biologics, and to identify infectious pathogens. In the future an individualized treatment could be tailored according to synovial histology.

Conflict of Interest

None.

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