Application of Ultrasound-guided Core Biopsy in Head and Neck

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Abstract  Head and neck tumor is frequently encountered clinically, but the list of differential diagnosis of neck lumps is lengthy. Consequently, the major concern of diagnostic procedure is to effectively narrow the possibility, and finally make an accurate diagnosis. Ultrasound-guided core biopsy (USCB) has been well established in many medical fields as the standard tissue sampling procedure, with less harm than open biopsy (OB) and more pathological information than ultrasound-guided fine needle aspiration (USFNA). In addition, using the small-cutting needle, USCB can be easily and safely performed for head and neck lesions. In this review, we present our optimal procedure of applying USCB and review its roles in head and neck, including cervical lymph nodes, thyroid tumors, salivary tumors, pediatric head and neck lesions, cervical infectious diseases, head and neck cancer and aerodigestive tumors. The procedure-related bleeding and tumor seeding are rarely reported even after 7-year follow up in the literature. The head and neck surgeons are competent to take care of any unpredictable complications caused by USCB. According to our experience, USCB can be utilized as a powerful tool in surgeon’s hands to explore the possibilities of doing tissue sampling in many areas of head and neck.

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KEYWORDS
Ultrasound,
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Introduction

Head and neck tumor is frequently encountered clinically, and a complete evaluation of head and neck fields is the first step to make the differential diagnosis. To make the definite diagnoses of head and neck tumors, numerous disease entities should be differentiated, including congenital anomalies, infectious and inflammatory diseases, and neoplastic lesions [1]. The origins of cervical tumors include lymph node, major salivary glands, thyroid, neurogenic tumor, vascular tumor, congenital cyst, acquired abscess, or hematoma. Because of the lengthy list of differential diagnoses of neck lumps, the major role of diagnostic procedures is to effectively narrow the possibility, and finally make an accurate diagnosis. Tissue sampling is regarded as the standard procedure to make the final diagnosis.

Conventionally, the standard tissue sampling methods of head and neck tumors include open biopsy (OB) and ultrasound-guided fine needle aspiration (USFNA). OB always provides sufficient specimens that help make the final pathological diagnosis. However, creation of a surgical wound and anesthesia are required for OB procedures. It is especially not favorable for women because esthetic outcome is always cause for concern. In addition, OB is contraindicated for infirm patients who cannot tolerate general anesthesia. USFNA can precisely harvest cells from the target lesions with only a small needle puncture wound. Because only cells are harvested for evaluation, the specimen read by an experienced cytopathologist is important for obtaining the correct diagnosis. Though immediate on-site interpretation of USFNA results can improve diagnostic accuracy by reducing inadequate sampling, it is expensive and not affordable by many health care systems [2].

The application of ultrasound-guided core biopsy (USCB) in head and neck lesions has recently drawn much attention. In addition to having a high diagnostic rate, USCB demonstrates diagnostic accuracy similar to that of OB, but with a lower complication rate [10]. It also bears minimal risk of tumor spreading in renal tumor diagnosis [9]. A systematic review proves the role of USCB in pediatric tumors, which was associated with a 94% biopsy adequacy rate, 94% diagnostic adequacy rate, and 1% complication rate [8]. USCB had also been used to diagnose thyroid nodules, with 87% adequacy and zero false-negative rates [11]. It was concluded that USCB is an accurate and safe alternative to USFNA in the assessment of thyroid nodules. For the head and neck, USCB has been used in the diagnosis of many diseases. For example, USCB for diagnosing superficial lymphadenopathy, especially in the neck and axilla, was first developed in Taiwan. Other disease entities, including metastasis of malignancy, lymphoma, tuberculosis, Kikuchi-Fujimoto disease, and benign lymphoid hyperplasia has also been diagnosed by USCB [6].

Optimizing the procedure of applying USCB for head and neck tumors

Though it is possible to apply USCB techniques in head and neck regions, the procedure routinely used in other medical fields certainly is not useful for diagnosing head and neck tumors. The 12–16-gauge cutting needles, which are frequently used in USCB, are originally designed for breast and abdominal lesions. They had been used for diagnosing head and neck lesions [12]. It is believed that large-gauge needles are associated with an increased possibility of procedure-related complications, such as bleeding, wound dehiscence, anesthetic requirement, and tumor seeding potential [13]. The head and neck is a restricted anatomical space with many complex and delicate structures. Diagnostic intervention should be less invasive to prevent any related morbidity. Therefore, using cutting needles with large gauges is clinically impractical for head and neck tumors. We attempted to optimize the USCB procedure for head and neck tumors [14]. Using the small cutting needle, such as breast lesions, USCB demonstrates diagnostic accuracy similar to that of OB, but with a lower complication rate [10]. It also bears minimal risk of tumor spreading in renal tumor diagnosis [9]. A systematic review proves the role of USCB in pediatric tumors, which was associated with a 94% biopsy adequacy rate, 94% diagnostic adequacy rate, and 1% complication rate [8]. USCB had also been used to diagnose thyroid nodules, with 87% adequacy and zero false-negative rates [11]. It was concluded that USCB is an accurate and safe alternative to USFNA in the assessment of thyroid nodules. For the head and neck, USCB has been used in the diagnosis of many diseases. For example, USCB for diagnosing superficial lymphadenopathy, especially in the neck and axilla, was first developed in Taiwan. Other disease entities, including metastasis of malignancy, lymphoma, tuberculosis, Kikuchi-Fujimoto disease, and benign lymphoid hyperplasia has also been diagnosed by USCB [6].
USCB is easily performed for head and neck lesions. In addition, the current progress made in ultrasound resolution helps improve imaging quality during USCB for head and neck tumors. Currently, USCB is one of the standard diagnostic tools for head and neck tumors in many medical institutions.

Procedures of USCB in head and neck tumor

The patient was placed in a supine position with the neck hyperextended. The neck skin was disinfected and draped following the standard antiseptic procedure. A panoramic ultrasound examination of the head and neck was first performed with a 12 MHz linear probe. Sonographic features and the location of targeted lesions were evaluated. A color-duplex model was used to mark vasculature to avoid vascular injury during the procedure. After the safest path to the target tumor was identified, local anesthesia (0.001% epinephrine + 2% lidocaine solution) was injected subcutaneously around the area of the needle puncture. Under ultrasound guidance, an 18-gauge biopsy needle (Temno Evolution Biopsy Devices, Cardinal Health Inc., Dublin, Ohio USA) was inserted without skin incision for sampling (Fig. 1). Two notch sizes (10 mm or 20 mm) could be selected depending on the size and the anatomical location of the tumor. After tissue harvesting, the specimen was removed from the needle notch, checked for quality and quantity, and fixed in formalin solution (Fig. 2). One tissue sample was collected. If the tissue quality and quantity was not good enough in gross examination, a second sample was obtained. All samples were sent to the pathology department for staining and microscopic examination. After the procedure, oozing from the puncture wound was controlled with pressure for 5 minutes. The patient was observed for 30 minutes. If there were no signs of complications, the patient was then discharged. The applications of USCB in the head and neck are summarized in Table 1.

USCB for cervical lymph nodes

Using USCB to diagnose cervical lymphadenopathy was first reported 1 decade ago [6]. To differentiate benign from malignant lymphadenopathy, USCB was reported to have high sensitivity (98.1%), specificity (100%), and accuracy (98.7%). However, USCB also had high sensitivity, specificity, and accuracy in differentiating lymphoma from reactive lymphadenopathy [15]. In a prospective study using USCB with 18- or 20-gauge needles, only 17% patients in whom lymphoma was diagnosed needed additional OE to obtain more subtyping information for treatment [16]. Recent literature has also proved the applications of USCB in confirming malignant lymphoma [17,18] and metastatic cervical lymph nodes [3]. Accordingly, using USCB for diagnosing cervical lymph nodes provides similar pathological information as OB, but only creates a wound as small as USFNA, even for diagnosing lymphoma. In benign lymphoid hyperplasia or self-limited disease such as Kikuchi-Fujimoto disease, USCB can prevent unnecessary invasive diagnostic procedures by surgical intervention [19].

USCB for thyroid tumors

The USFNA is regarded as the first-line diagnostic tool for thyroid nodules. However, inadequate specimens and
nondiagnostic results (10–33.6%) are frequently encountered during USFNA [20]. When compared with USFNA, higher adequacy (87%), lower false-negative rate (zero), and fewer patients who required further surgical confirmation (11%) could be achieved by USCB in thyroid lesions. USCB also minimized the nondiagnostic results of calcified thyroid nodules that used to be confirmed by OB [21]. In addition, no major complications were noted using USCB for thyroid lesions [11]. Although the adequate rate of USCB was significantly higher than that of USFNA (70.3%), not all thyroid nodules are suitable for USCB. It has been reported that USCB had less sensitivity in diagnosing papillary carcinoma [22]. The combination of USFNA with USCB may improve adequacy and sensitivity of diagnosing thyroid lesions [22]. The single-shot technique of thyroid lesions that permitted the rapid acquisition of tissue samples by both USFNA and USCB facilitated diagnostic yields [23]. In addition, USCB has an important role in confirming thyroid lymphoma, and the cases of indeterminate thyroid nodules sampled by repeated USFNA [24,25].

Although USCB may provide more information on thyroid lesions than USFNA, a higher complication rate was also found in USCB, including hematoma and infection [26]. For thyroid lesions, the addition of USCB to USFNA confers little benefit in decreasing the nondiagnostic rates and may be associated with increased complications. Therefore, some reports suggested that USCB should not be routinely performed in the evaluation of thyroid nodules. For USCB, patient selection should be done judiciously [26].

### USCB for salivary tumors

To harvest tissue from parotid gland tumors, OB is not routinely suggested because of a high risk of facial nerve injury. The diagnostic accuracy of USCB for salivary tumors, including those of the parotid and submandibular glands, is reportedly high [27]. In addition, USCB also provided higher sensitivity than USFNA in differentiating benign from malignant lesions of the parotid gland [28]. More specific diagnoses could also be confirmed by USCB, including pleomorphic adenoma, Warthin tumor, and lymphoma [29,30]. Regarding the potential of procedure-related tumor seeding of USCB, only two cases of salivary tumor seeding were reported after literature review. For these two cases, USCB was performed with larger gauge needles (14–16 gauge) [13]. For small-caliber needles (18–20 gauge), the incidence has never been reported. There was no case showing tumor seeding after a 7-year follow up in a systematic review [24].

### USCB for pediatric head and neck lesions

The first application of USCB in pediatric tumors demonstrated good tolerance under local anesthesia [31]. A variety of diagnoses were confirmed solely by USCB, including Hodgkin disease, T-cell lymphoma, parotid hemangioma, and granulomatous inflammation [31]. These diagnoses confirmed by USCB prevent additional invasive biopsy

<table>
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<th>Summary of ultrasound-guided core biopsy in head and neck applications.</th>
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<td>Indications</td>
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<td>Cervical lymph nodes</td>
<td>Ultrasound-guided core biopsy has high sensitivity, specificity, and accuracy in differentiating benign from malignant lymphadenopathy and lymphoma from reactive lymphadenopathy.</td>
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<td>Thyroid tumors</td>
<td>When compared with ultrasound-guided fine needle aspiration, higher adequacy, lower false-negative rate, and fewer patients who needed further surgical confirmation could be achieved by ultrasound-guided core biopsy in thyroid lesions without major complication. The combination of ultrasound-guided fine needle aspiration with ultrasound-guided core biopsy may improve adequacy and sensitivity of diagnosing thyroid lesions. Not all thyroid nodules are suitable for ultrasound-guided core biopsy, so patient selection should be done judiciously.</td>
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<td>Salivary tumors</td>
<td>Ultrasound-guided core biopsy in salivary tumors, including parotid and submandibular glands, has high diagnostic accuracy and confirms specific diagnoses. No case showed tumor progression after a 7-year follow up.</td>
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<td>Pediatric head and neck lesions</td>
<td>A variety of diagnoses can be confirmed solely by ultrasound-guided core biopsy, avoiding further invasive biopsy procedures in pediatric patients. Ultrasound-guided core biopsy showed high biopsy and diagnostic adequacy rate, and low complication rate.</td>
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<td>Cervical infectious disease</td>
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<td>Head and neck cancer</td>
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<td>Aerodigestive tumors</td>
<td>Ultrasound-guided core biopsy is helpful for tissue sampling in patients who were not surgical candidates or failed to be diagnosed with hypopharyngeal cancer by conventional endoscopic approaches.</td>
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procedures in pediatric patients [31]. A systematic review also validated the role of USCB in pediatric tumors, showing a 94% biopsy adequacy rate, 94% diagnostic adequacy rate, and 1% complication rate [8].

USCB for cervical infectious diseases

Most patients with extrapulmonary tuberculosis present with cervical lymphadenopathy. USFNA is the most common initial diagnostic procedure, but sensitivity is low. OB is regarded as the gold standard for pathological confirmation, but complications such as infection, scarring, nerve injury, and longer-term discharge sinus frequently occur. Using USCB, the sensitivity (95%) is equivalent to that of OB (91%). Consequently, USCB can be used as the first-line diagnostic procedure for suspected extrapulmonary tuberculosis [32].

USCB for head and neck cancer

In head and neck cancer, USCB is a safe and efficient tool for tissue harvest [12]. When guided by ultrasound, USCB could be easily performed in the outpatient clinic for immediate tissue sampling [15]. In order to set "one stop" clinics in the investigation and diagnosis of head and neck tumors, the National Institute for Clinical Excellence (NICE) guidelines in the United Kingdom recommend ultrasound-guided tissue sampling methods. When compared with FNA, USCB with small-bore needles (18- or 20-gauge) has the advantages of higher accuracy, good tolerance, and minimal invasiveness, even without on-site cytologists [33]. Its role as a complementary procedure had been adopted by nonsurgical candidates or after repeated FNA failure [34]. In the nonsurgical or palliative settings, USCB provides a simple and fast tissue sampling method to obtain early diagnoses [35]. For example, for those patients who received radiotherapy as the primary treatment, USCB can be used to confirm the diagnosis without surgical intervention. For occult lymph node metastasis and locoregional recurrence, ultrasound can be used for screening. When combined with core biopsy, USCB facilitates early detection of recurrence during follow-up.

USCB for aerodigestive tumors

Aerodigestive tumors such as tongue base [36], supraglottic cancer [37], and hypopharyngeal tumors [38, 39] potentially can be visualized by transcutaneous ultrasound. Hypopharyngeal cancer remains a clinical challenge among head and neck malignancies because of its poor prognosis [40]. Clinically, microlyrngosurgery is regarded as the standard procedure for diagnosing oropharyngeal and hypopharyngeal cancer. Microlyrngosurgery routinely serves as a sampling method to harvest tissue for pathological examination [41, 42]. Unfortunately, many patients with hypopharyngeal cancer in an endemic area of betel nut chewing, such as Taiwan, often simultaneously have trismus and limited neck extension, which makes the rigid laryngoscopy procedure difficult [43]. In elusive hypopharyngeal cancer presenting with submucosal extension and intact mucosa, it is sometimes difficult to identify the location and delineate the extension of tumors by direct vision through a laryngoscope. Flexible endoscopy is performed without general anesthesia; therefore, it serves as an alternative for rigid laryngoscopy. However, because of the small size of flexible endoscopic biopsy instruments, harvesting of a deep-seated tumor is difficult [43].

Ultrasoundography allows for a comprehensive evaluation of the depth of soft-tissue extension of tumors and real-time monitoring of the biopsy procedure. Ultrasoundography is an office-based procedure with a low medical cost. General anesthesia is not required, and the duration is short. Because of these advantages, USCB can overcome the drawbacks noted in the aforementioned sampling procedures. Although the hypopharynx has been proved to be visible and evaluable by ultrasound, only a limited number of studies have attempted core biopsy to harvest tumor specimens [42, 44]. The role of USCB in hypopharyngeal cancer was first reported by us showing the feasibility of using USCB for tissue sampling in patients who were not surgical candidates or who did not receive a diagnosis of hypopharyngeal cancer by conventional endoscopic approaches [45, 46].

Potential complications of applying USCB in the head and neck

The potential complications of applying USCB for head and neck tumors are bleeding and tumor seeding. Coupled with Doppler mode, ultrasound guidance can help identify the vascular tumor and avoid major vessels during the procedure. The incidence of bleeding is 1%, and most tumors are mild hematomas without major bleeding [24]. No mortality by USCB has ever been reported.

Tumor seeding after transcutaneous cutting needle biopsy in the head and neck was rarely reported [47]. According to the literature, using smaller needles for USCB never showed tumor seeding, even after a 7-year follow-up [24, 29].

Selection of the gauge size of the core needle

For lymphoma diagnosis, a large needle size increases diagnostic yields. The 14-gauge needles confirmed 100% of cases with lymphoma, and only 11% required further biopsy for subtyping [17]. The 18-gauge needles confirmed only 83% lymphoma diagnoses, and 18% needed further biopsy for subtyping [17]. However, most studies using 18–20-gauge needles for head and neck tumors provided acceptable pathological information, but with few complications [3, 28, 29, 48].

Therefore, as the first-line diagnostic tool or complementary role to USFNA, USCB with a small-caliber needle can provide diagnostic accuracy with minimal invasiveness [14].

Who performs the USCB?

The blind FNA guided by hand palpation had served as a standard procedure for head and neck tumors, and can be performed by most physicians clinically. However, the
ultrasound-guided invasive procedures were mostly performed by specialists. Ultrasound guidance is an extension of the physical examination, especially for the deep-seated masses [49]. It had been reported that USFNA yielded a higher diagnostic rate in comparison with standard palpation technique [50]. Because they are familiar with the anatomy of the head and neck, head and neck surgeons can harvest the target lesion by themselves to avoid communication errors between clinical doctors and radiologists. The head and neck surgeons have the competence to take care of any unpredictable complications caused by USCB. According to our experience, USCB can be used as a powerful tool by surgeons to explore the possibility of tissue sampling in many areas of the head and neck, such as the tongue base, supraglottis, parapharynx, hypopharynx, and larynx.

Conclusion

Head and neck tumors are common. The use of simple, convenient, safe, rapid, and minimally invasive procedure to obtain enough tissue samples for making the accurate diagnosis is always appealing. Assisted by advanced ultrasonography and biopsy instruments, USCB is suggested as one of the important diagnostic tools for head and neck tumors.

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