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TUMOR

The "Triple-Overlay" Technique for Percutaneous Diagnosis and Treatment of Lesions of the Head and Neck: Combined Three-Dimensional Guidance with Magnetic Resonance Imaging, Cone-Beam Computed Tomography, and Fluoroscopy

Michael R. Levitt[1], Sandeep S. Vaidya[2], David K. Su[1], Kris S. Moe[3], Louis J. Kim[1,2], Laligam N. Sekhar[1], Danial K. Hallam[1,2], Basavaraj V. Ghodke[1,2]

Key words
- Cone-beam computed tomography
- Interventional fluoroscopy
- Magnetic resonance imaging

Abbreviations and Acronyms
3D: Three-dimensional
CBCT: Cone-beam computed tomography
CTA: Computed tomographic angiography
DICOM: Digital Imaging and Communications in Medicine
FLAIR: Fluid-attenuated inversion recovery
MRI: Magnetic resonance imaging
PET: Positron emission tomography

From the Departments of [1]Neurological Surgery, [2]Radiology, and [3]Otolaryngology, University of Washington and Harborview Medical Center, Seattle, Washington, USA

To whom correspondence should be addressed: Michael R. Levitt, M.D. [E-mail: mlevitt@u.washington.edu]

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■ OBJECTIVE: **Accurate image guidance is an essential component of percutaneous procedures in the head and neck. The combination of preprocedural magnetic resonance imaging (MRI) with cone-beam computed tomography (CBCT) and real-time fluoroscopy (the "triple-overlay" technique) could be useful in image-guided targeting of lesions in the head and neck.**

■ METHODS: **Three patients underwent percutaneous diagnostic or therapeutic procedures of head and neck lesions (mean, 2.3 ± 2.4 cm). One patient presented for biopsy of a small lesion in the infratemporal fossa only visible on MRI, one presented for preoperative embolization of a nasal tumor, and one presented for sclerotherapy of a parotid hemangioma. Preprocedural MRI for each case was merged with CBCT to create a three-dimensional volume for procedural planning. This was then combined with real-time fluoroscopy to create a triple-overlay for needle trajectory and real-time guidance.**

■ RESULTS: **The registration of MRI, CBCT, and fluoroscopy was successful for all three procedures, allowing 3D manipulation of the combined images. Percutaneous procedures were successful in all patients without complications.**

■ CONCLUSIONS: **The combination of MRI, CBCT, and real-time fluoroscopy provides detailed anatomical information for 3D image-guided percutaneous procedures of the head and neck, especially for small lesions or lesions with features visible only by MRI.**

INTRODUCTION

Percutaneous access to lesions of the head and neck is a well-established method of diagnosis and treatment (4). The advanced features on contemporary angiographic workstations permit the merging of preprocedural imaging with fluoroscopy for diagnosis and treatment (5, 6, 15). By combining the excellent spatial resolution and soft-tissue visualization of magnetic resonance imaging (MRI) with live fluoroscopic overlay, the practitioner can perform image-guided percutaneous procedures with excellent accuracy and reduced radiation exposure (1, 21). Many fluoroscopic units are also equipped with cone-beam computed tomography (CBCT) for on-the-fly intraprocedural imaging and computed tomography (CT)-guided navigation (8, 10, 17-19, 21, 24, 25). The combination of MRI, CBCT, and fluoroscopy provides the most detailed anatomically accurate images for live, three-dimensional (3D) image-guided procedures, especially in the treatment of small soft-tissue masses best visualized with MRI and poorly seen on conventional CT.

The integration of preprocedural MRI, intraprocedural CBCT, and fluoroscopic guidance has been reported for endovascular catheter navigation (15), as well as the embolization of an intraorbital mass (5), with favorable results. Herein, we report our subsequent experience with three patients with head and neck pathology wherein combined triple-overlay imaging provided indispensable soft-tissue resolution for lesion diagnosis and treatment.

MATERIALS AND METHODS

Study Population

Informed consent and authorization via the Health Insurance Portability and Accountability Act was obtained for all patients. All procedures complied with the ethical guidelines of the institutional review board in this prospective study. There was no industry support. Patients age 18 or older were selected after referral for percutaneous interventional radiology—assisted procedures of head and neck lesions between February and April 2011. Three patients (two men, one woman; mean age, 51.3 years; age range, 32-74 years) were enrolled for study. Three diagnostic or therapeutic procedures of head and neck lesions (mean target diameter, 2.3 ± 2.4 cm; range, 9 mm to 5.1 cm) were performed. One patient presented for biopsy of a small lesion in the infratemporal fossa only visible on MRI, one presented for preoperative embolization of a nasal tumor, and one presented for sclerotherapy of a parotid hemangioma.

Image Overlay. All patients underwent preprocedural diagnostic MRI at our or another institution with and without the administration of gadolinium contrast; 3D MR sequences were obtained whenever possible. Each MRI was imported to the Xtra Vision 3DRA workstation (Philips Medical Systems, Eindhoven, the Netherlands) using the Digital Imaging and Communications in Medicine (DICOM) format. CBCT (XperCT; Philips Healthcare, Andover, Massachusetts, USA) was obtained at the start of each interventional procedure with the following parameters: scan time, 10.4 seconds; frame rate, 60 frames per second; detector field, 48 cm; total angle, 220° at 20°/second; resulting in a data set of 621 images. MRI sequences including T1 (with gadolinium contrast), fluid-attenuated inversion recovery, and T2 were selected from the preoperative scans and merged with the CBCT and fluoroscopy in each case to create a combined triple-overlay 3D volume for surgical planning.

Merging was accomplished by a proprietary linear alignment software algorithm, in which skull and ventricular contours were merged between the chosen MRI volume, the CBCT volume created at the time of the procedure, and the unsubtracted fluoroscopic image (5, 15, 21, 25). Automatic overlay was completed within seconds, and manual adjustments to the overlays were made if necessary. Because the CBCT and fluoroscopy are obtained in calibrated space, and the MRI information registered to these volumes, manipulation of the combined volume in 3D can be performed, including C-arm rotation, table movement, and zoom in/out. XperGuide planning software was then used by the operators in each case to define target and entry points for real-time fluoroscopic needle guidance (**Figure 1**). Real-time motion-correction software, in which the 3D volumes were realigned with fluoroscopy, was automatically used by the workstation when the patient's position on the table was changed for any reason; repeat CBCT was not required for motion correction.

Description of Procedures

All percutaneous procedures were performed by the senior authors (11 and 14 years of experience, respectively) in the neurointerventional suite using an Allura Xper FD 20-20 angiographic unit and Xtra Vision 3DRA workstation (Philips Medical Systems). All patients were placed under general anesthesia and positioned supine on the angiogram table. Each patient's head was positioned in a manner maximizing lesion exposure when necessary and secured to the angiography table with tape. The skin overlying the lesion as determined by the XperGuide planning software was marked, prepped, and draped in sterile fashion.

In all cases, XperGuide technique was used to access the target. First, a needle (specific type varying with procedure; see below) was aligned by the use of anteroposterior- or lateral-view fluoroscopy ("entry point view"; **Figure 1A**). The C-arm was then rotated 90° ("progress view"), and with combined MRI and CBCT overlay to visualize the needle progress, the needle was advanced to the target along the previously defined trajectory (**Figure 1B**), with the operator taking care to maintain needle alignment defined by both the entry point and progress views. By alternating between these views (**Video 1**), accurate trajectory was followed even for deep-seated or small lesions (21). The needle was advanced with the virtual targeting of the XperGuide software and fluoroscopy with the additional information from CBCT and MRI in the triple-overlay.

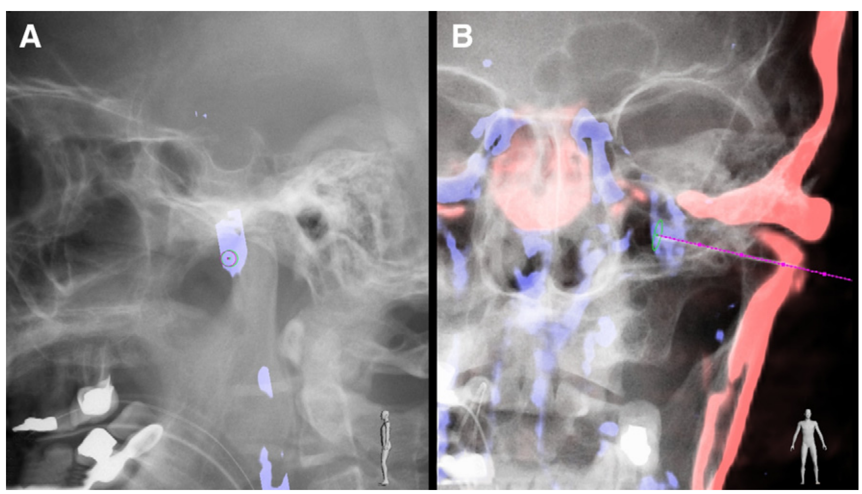

Figure 1. Needle alignment and progress with the use of XperGuide and fluoroscopy. The "entry point view" (**A**) superimposes the planned trajectory's entry point (*purple circle*) and target (*green circle*), to allow correct needle alignment. The edge of a thin coronal view of the preoperative MRI is seen. The "progress view" (**B**), rotated 90° from the entry point view, provides real-time depth guidance as the needle passes along the trajectory (*purple line*) towards the target (*green circle*). Components of magnetic resonance imaging are rendered in *blue*, cone-beam computed tomography in *pink*, and fluoroscopy in *grayscale*.