Performance of magnetic resonance imaging in the evaluation of first-time and reoperative primary hyperparathyroidism

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Background. *Preoperative imaging in patients with primary hyperparathyroidism and a previous parathyroid operation is essential; however, performance of conventional imaging is poor in this subgroup. Magnetic resonance imaging appears to be a good alternative, though overall evidence remains scarce. We retrospectively investigated the performance of magnetic resonance imaging in patients with and without a previous parathyroid operation, with a separate comparison for dynamic gadolinium-enhanced magnetic resonance imaging.*

Methods. *All patients undergoing magnetic resonance imaging prior to parathyroidectomy for primary hyperparathyroidism (first time or recurrent) between January 2000 and August 2015 at a high-volume, tertiary care, referral center for endocrine operations were included. We compared the sensitivity and positive predictive value of magnetic resonance imaging with conventional ultrasound and sestamibi on a per-lesion level.*

Results. *A total of 3,450 patients underwent parathyroidectomy, of which 84 patients with recurrent (*n *= 10) or persistent (*n *= 74) disease and 41 patients with a primary operation were included. Magnetic resonance imaging had a sensitivity and positive predictive value of 79.9% and 84.7%, respectively, and performance was good in both patients with and without a previous parathyroid operation. Adding magnetic resonance imaging to the combination of ultrasound and sestamibi resulted in a significant increase in sensitivity from 75.2% to 91.5%. Dynamic magnetic resonance imaging produced excellent results in the reoperative group, with sensitivity and a positive predictive value of 90.1%.*

Conclusion. *Technologic advances have enabled faster and more accurate magnetic resonance imaging protocols, making magnetic resonance imaging an excellent alternative modality without associated ionizing radiation. Our study shows that the sensitivity of multimodality imaging for parathyroid adenomas improved significantly with the use of conventional and dynamic magnetic resonance imaging, even in the case of recurrent or persistent disease. (Surgery 2016;160:747-54.)*

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Primary hyperparathyroidism (pHPT) is one of the most common endocrine disorders with an estimated incidence of 45 cases per 100,000 person-years.[1] An operation is the only curative treatment recommended for patients who are <50 years old or who have clinical symptoms.[2] Although 95% of patients can be successfully treated with cervical exploration without preoperative imaging, most centers currently use 99tc-sestamibi scintigraphy (MIBI) and ultrasound (US) to localize hyperfunctioning glands, allowing surgeons to perform a minimally invasive parathyroidectomy (MIP).[3-7]

As repeat cervical exploration carries a higher risk of complications and the success rate is lower, preoperative imaging is recommended when patients have recurrent or persistent pHPT.[8,9] In this patient group, localization studies enable a directed

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operative approach with a higher success rate and fewer complications.[10] US and MIBI can also be used for parathyroid localization in this patient group but are more often negative or inconclusive.[11]

As most surgeons prefer to have ≥2 concordant imaging studies prior to reoperation, other imaging studies may also be used for localization of abnormal parathyroid glands. Due to its high spatial resolution, short acquisition time, and relatively low cost, computed tomography (CT) has been studied the most.[12,13] The 2006 description and subsequent adoption of multiphase CT imaging (4DCT) of the neck and hypervascular parathyroid glands have significantly improved diagnostic accuracy.[14-17] A major disadvantage of the 4DCT protocol is a substantial increase in radiation exposure associated with scanning in multiple contrast phases.[18]

Alternatively, neck magnetic resonance imaging (MRI) does not deliver ionizing radiation, and previous studies have shown overall good performance of this modality for detection of enlarged parathyroid glands.[19-25] Recent technologic developments have culminated in dynamic MR protocols analogous to 4DCT but without the disadvantage of radiation exposure. Pilot studies of dynamic gadolinium-enhanced MR have shown excellent results.[26,27] Gadolinium-enhanced MR uses differences in time-to-peak, washout, and peak enhancement to distinguish hypervascular parathyroid adenomas from surrounding lymph nodes and thyroid tissue.[27]

Despite these advances, overall evidence regarding the use of MRI remains scarce, especially in cases of recurrent or persistent disease. The purpose of the current study was to compare the sensitivity and positive predictive value (PPV) of MRI with conventional US and MIBI in patients with and without a previous parathyroid operation, with a separate comparison for dynamic gadolinium-enhanced MRI.

METHODS

This study was approved by the Committee on Human Research, the institutional review board of the University of California, San Francisco (UCSF).

We performed a retrospective review of all patients undergoing MRI prior to parathyroidectomy for pHPT between January 2000 and August 2015 at a high-volume, tertiary care, referral center for endocrine operations. Patients undergoing an initial operation as well as an operation for recurrent or persistent disease were eligible. Patients were included when the following criteria were met: (1) at least 18 years of age and (2) biochemically proven pHPT with elevated serum calcium and inappropriate normal or high levels of parathormone (PTH). Patients were excluded based on the following criteria: (1) MRI performed at a different center, (2) familial pHPT, or (3) no cure after operation. Reference level for calcium was 8.8–10.3 mg/dL, and for intact PTH 12–65 ng/L.

In our institution, patients with initial presentation of pHPT or with recurrent/persistent disease underwent both US and MIBI. Occasionally, MRI was performed at initial presentation instead of MIBI; MRI was also performed when there was inconclusive conventional imaging or a need for high-resolution cross-sectional imaging. In patients with recurrent or persistent disease, MRI was performed as standard in addition to US and MIBI.

Ultrasound. A diagnostic US was performed by an experienced ultrasonographer in the Department of Radiology. A high-frequency linear transducer was used to image the neck with the patient in the supine position and the neck extended. The cervical neck from the mandible to the sternal notch was interrogated. Transverse and longitudinal images were used to locate suspicious glands, which were evaluated using B-mode and color Doppler.

99mTc-sestamibi scintigraphy. Patients underwent 99mTc-sestamibi studies using 25 mCi of radiotracer. Patients were studied either using planar imaging or single-photon emission CT (SPECT) imaging. Planar imaging using a parallel whole collimator was obtained at 15 minutes and 2 hours postinjection. Subsequently, a SPECT/CT extending from the mandible to the aortic arch was obtained.

MRI protocol. Our initial protocol included a small field of view axial T1, axial T2 with fat saturation, and postgadolinium axial T1 with fat saturation as previously described.[22] In 2010, axial dynamic acquisitions were included in the protocol, which included 4 dynamic axial postcontrast T1 phases prior to the high-resolution axial T1 acquisition. Single-dose gadolinium was administered at 0.1 mL/kg for postcontrast imaging. The majority of studies were performed at 1.5T (n = 102), with the remainder performed at 3.0T (n = 23). Focusing on the typical locations for parathyroid glands and the common sites of ectopic glands, the neck was scrutinized for ovoid T2 intense and enhancing lesions.

Interpretation of imaging. All imaging studies (US, MIBI, and MRI) were reviewed retrospectively using the original radiology reports. Ultrasounds that were performed by a surgeon without an official radiology report were not included for