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High-resolution ultrasonography is a more useful primary diagnostic tool than magnetic resonance imaging for subungual glomus tumors: a single-center retrospective study

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Purpose: Ultrasonography (US) and magnetic resonance imaging (MRI), which has better resolution, have been suggested as appropriate diagnostic tools for digits; however, comparative studies of both modalities are scarce. This study compared the diagnostic performance of high-resolution US and MRI in characterizing subungual glomus tumors.

Methods: We retrospectively analyzed the data of consecutive patients who were examined with high-resolution US and MRI before surgical exploration for subungual tumors from January 2017 to April 2020. The patients' clinical data and radiological findings were collected. Historical reports for diagnostic confirmation and measurements of mass size were reviewed. We conducted the McNemar test and evaluated the degree of agreement between the size measurements made using both techniques.

Results: Overall, 22 patients (age range, 19–72 years) underwent surgical exploration and had subungual glomus tumors. The mean duration from initial symptom presentation to diagnosis was 7 years (range, 5–30) years. Only nine patients (40.9%) presented with the symptomatic triad of pain, cold sensitivity, and tenderness. MRI detected lesions in 19 cases (86.4%); three cases (13.6%) were undetected. Contrastingly, US was able to detect all lesions. Nine patients (40.9%) had visibly rich blood flow in tumor tissues on Doppler US. MRI and US showed bone erosion in eight and 15 cases, respectively.

Conclusion: The detection rate of high-resolution US for subungual glomus tumors was as high as that of MRI. US can be applied easily and quickly and can be more useful as a primary diagnostic tool.

Keywords: Glomus tumor, Diagnostic imaging, Magnetic resonance imaging, Ultrasonography

Introduction

Glomus tumors are rare benign hamartomas of vascular origin that arise from glomus bodies [1]. They account for 1% to 4.5% of all hand tumors [2] and often exhibit a classic presentation of pain, cold sensitivity, and exquisite point tenderness. Imaging studies are commonly performed in cases where patients do not present with typical symptoms and to localize the lesion before complete surgical removal. Recent studies emphasize the use of imaging investigations, such as magnetic resonance imaging (MRI) and ultrasonography (US) for the diagnosis and planning of surgical management [3,4].

Although several other sites have been reported in the literature, one of the most common sites for this tumor is the subungual region. Because of the high concentration of glomus bodies in the area, 75% to 90% of glomus tumors occur in the subungual tissue [5]. These tumors cause severe pain and disability despite the presence of only subtle clinical signs that can be easily missed during meticulous clinical examination [6]. With the technical development of modalities with better resolution and less noise, US has shown good performance in visualizing small bones and joint anatomy [7]. MRI also has improved spatial resolution, allowing the observation of small lesions; however, there are only a few reports of subungual glomus tumor evaluation. Therefore, this study aimed to compare the diagnostic performances of high-resolution US and MRI in characterizing subungual glomus tumors.

Methods

Ethics statement: This study was approved by the Institutional Review Board of Korea University Anam Hospital (No. 2020 20AN0354). It was performed in accordance with the Declaration of Helsinki, and written informed consent was waived due to its retrospective nature.

From January 2017 to April 2020, we retrospectively reviewed the data of 34 patients who underwent surgical treatment for subungual tumors in a single tertiary hospital. Of these patients, 22 patients were examined using MRI and US before surgical exploration for subungual tumors and were included in this study. The clinical data and radiologic findings of MRI and US were collected, and diagnostic confirmation and measurement of the mass size were performed by histological analysis.

We acquired MRI data of the affected fingers using a 3.0-T Philips Achieva Nova Dual MRI scanner (Philips, Best, Netherlands). MRI was performed on a 3-T machine with a dedicated multichannel hand and wrist coil. Our standard protocol included proton density fat-suppressed T1-weighted coronal imaging, T2- and T1-weighted sagittal imaging, T2-weighted fat-suppressed axial imaging, and contrast-enhanced T1-weighted fat-suppressed coronal and axial imaging.

All US examinations were performed using a Philips EPIQ 7 Ultrasound Machine (Philips, Bothell, USA) or Toshiba Aplio 500 TUS-A500 ultrasound machine (Toshiba, Tokyo, Japan) with probe frequencies of 7.0 to 17.0 MHz. We measured the masses and detected bony erosions (breaks in the hyperechoic outline of the bony cortex) on the underlying phalangeal bone. Furthermore, we assessed the vascularity of the masses using power and color Doppler US. A radiologist with more than 10 years of experience in musculoskeletal diseases performed all the MRI and US examinations. Regardless of the presence or absence of bone lesions, the radiologist classified the MRI studies as negative if a tumor was not identified in the conventional MRI sequence. In addition, the radiologist defined US studies as "glomus tumor less likely" when the US confirmed the masses, but color Doppler showed no bony erosion lesions and no increased vascularity. Imaging studies confirmed the location and size of the subungual tumor. In all cases, a senior surgeon performed the surgery using a periungual approach to avoid surgically induced nail deformity.

Statistical analysis

We compared the sensitivity of the two imaging techniques using the McNemar test. Kappa statistics were used to evaluate the degree of agreement regarding the size of the tumor. We interpreted the kappa values according to the Landis and Koch criteria [8], which suggested almost perfect agreement for a kappa value of >0.80, substantial agreement for 0.61 to 0.80, moderate agreement for 0.41 to 0.60, fair agreement for 0.21 to 0.40, slight agreement for 0 to 0.20, and poor agreement for a negative kappa value. All the statistical analyses were performed using the IBM SPSS Statistics Base ver. 22.0 (IBM Corp., Armonk, NY, USA). Here, a p-value of <0.05 was statistically significant.

Results

A total of 22 patients (17 females and five males) with a mean age of 47 years (range, 19–72 years) underwent surgical exploration and were found to have subungual glomus tumors. The mean duration from the initial symptoms to diagnosis was 7 years (range, 5–30 years). In terms of the distribution of tumors on the fingers, the thumb was the most common site (eight cases), followed by the fourth (five cases) and third fingers (four cases). Only nine of 22 patients (40.9%) experienced the classic symptomatic triad of pain, cold sensitivity, and exquisite point tenderness. Cold hypersensitivity was the least frequent symptom, with 12 cases in the experimental group (54.5%). On visual inspection, we noted 14 and seven cases of nail discoloration and deformity, respectively (Table 1).

MRI located the lesion in 19 of 22 cases (86.4%); in the other three cases, MRI classified the mass as an enhanced signal (Fig. 1). In patients with positive MRI results, the mean tumor size was 4.7 mm (range, 2.2–7.5 mm). In the three undetected cases,

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Table 1. Patients' characteristics

Case No.	Sex	Age (yr)	Symptom duration (mo)	Involved finger	Lesion location	Blushed nail	Nail deformity	Symptom triad			Bony erosion on X-rays
								Spontaneous pain	Local tenderness	Cold hypersensitivity	
1	Female	46	84	4	Peripheral	P	N	P	P	N	P
2	Female	46	84	2	Peripheral	P	N	N	P	P	N
3	Female	52	6	5	Peripheral	N	N	P	P	N	P
4	Female	56	60	1	Central	P	N	P	P	N	P
5	Female	74	240	5	Peripheral	N	N	P	P	P	N
6	Female	36	12	1	Peripheral	N	N	P	P	P	P
7	Female	72	120	3	Peripheral	P	N	P	P	P	N
8	Female	30	72	1	Peripheral	N	P	P	P	P	N
9	Female	57	96	5	Peripheral	P	P	N	P	P	P
10	Male	48	24	1	Central	P	P	P	P	P	N
11	Female	54	120	3	Central	N	P	P	P	P	P
12	Male	60	60	2	Peripheral	N	N	P	N	N	N
13	Female	19	60	1	Peripheral	P	P	P	P	P	N
14	Male	35	48	4	Peripheral	P	N	P	P	N	N
15	Male	28	5	4	Central	P	N	N	P	N	N
16	Male	53	36	4	Central	N	N	P	N	N	N
17	Female	63	360	3	Peripheral	P	P	P	P	P	N
18	Female	59	60	1	Peripheral	P	N	P	P	N	P
19	Female	26	144	3	Peripheral	P	N	P	P	N	P
20	Female	50	120	1	Central	P	P	N	P	N	P
21	Female	29	24	1	Peripheral	N	N	P	P	P	P
22	Female	27	48	4	Central	P	N	P	P	P	P

P, positive; N, negative.

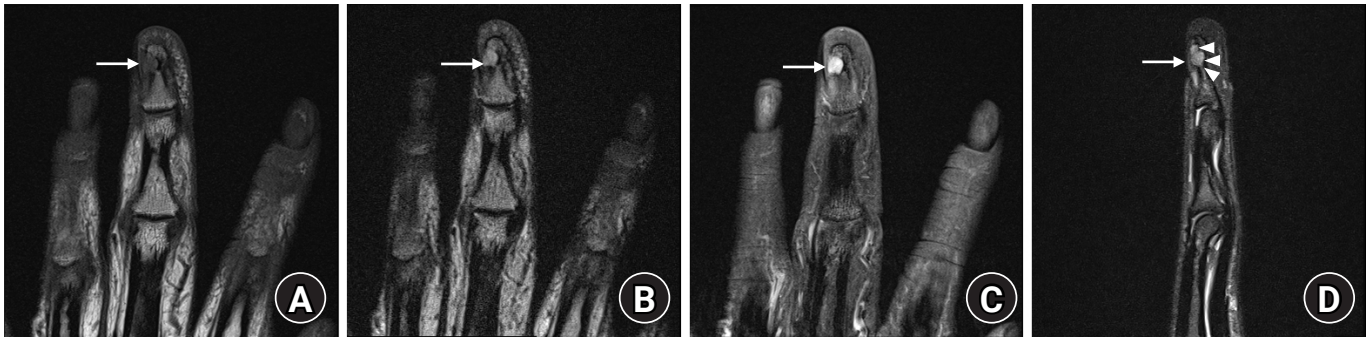

Fig. 1. Representative magnetic resonance image of a glomus tumor. A well-circumscribed mass was visible under the proximal aspect of the nail plate and matrix. (A) The mass (arrow) was isointense on T1-weighted images. (B, C) The mass (arrows) was hyperintense on T2-weighted and T1-enhanced images, respectively. (D) Dorsal bone erosion in the distal phalanx (arrowheads).

the lesion had a mean diameter of 2.4 mm on the pathology reports. In contrast, US detected all lesions, while four of 22 cases (18.2%) were classified as "glomus tumor less likely." Patients with positive US results had tumor sizes ranging from 1.9 to 7.1 mm (mean, 4.4 mm). Moreover, nine of the 22 tumor tissues (40.9%) had rich blood flow that was visible on Doppler US.

MRI and US showed bone erosion in eight (36.4%) and 15 (68.2%) of 22 cases, respectively, in the underlying phalangeal bone. In 11 patients, both MRI and US revealed bone erosion (Table 2).

MRI and US did not show a discrepancy in sensitivity with respect to detecting subungual glomus tumors ($p = 0.25$, two-tailed McNemar test). In terms of the degree of agreement for size measurement, MRI and US largely paralleled the gamma co-

Table 2. Features of lesions on MRI and US

Case No.	Bony erosion on X-rays	MRI			US				Pathological size (mm)
		Identified	Bone erosion	Size (mm)	Identified	Bone erosion	Rich blood flow	Size (mm)	
1	P	Yes	P	6.1	Yes	N	P	5.0	7.5
2	N	Yes	N	3.5	Yes	N	N	3.8	4.4
3	P	Yes	N	2.2	Yes	N	N	2.3	2.0
4	P	Yes	N	3.9	Yes	P	N	3.1	3.8
5	N	Yes	N	6.4	Yes	P	N	7.0	4.3
6	P	Yes	P	3.0	Yes	P	N	2.4	2.4
7	N	Yes	P	4.1	Yes	N	P	4.0	4.2
8	N	Yes	N	5.0	Yes	P	P	5.5	3.9
9	P	Yes	P	3.7	Yes	P	N	4.0	3.0
10	N	Yes	N	4.5	Yes	P	P	5.4	6.3
11	P	Yes	N	3.5	Yes	P	N	5.2	3.7
12	N	No	N	0	Yes	N	N	4.0	3.0
13	N	Yes	N	4.4	Yes	P	P	5.3	5.8
14	N	Yes	N	4.1	Yes	P	N	3.7	3.5
15	N	No	N	0	Yes	N	N	1.9	2.7
16	N	No	N	0	Yes	N	P	1.9	1.4
17	N	Yes	N	6.3	Yes	P	P	7.1	5.6
18	P	Yes	P	3.8	Yes	P	P	4.3	4.6
19	P	Yes	N	6.4	Yes	P	N	3.7	6.3
20	P	Yes	P	7.5	Yes	P	P	7.1	6.8
21	P	Yes	P	4.7	Yes	P	N	4.8	5.2
22	P	Yes	P	6.2	Yes	P	N	4.8	4.6

MRI, magnetic resonance imaging; US, ultrasonography; P, positive; N, negative.

efficient of 1, and the kappa coefficient was 0.771 ($p < 0.001$).

Discussion

Although subungual glomus tumors are characterized by considerable pain and cold hypersensitivity in the affected finger, not all lesions present with typical symptoms. In such cases, the diagnosis may be challenging, resulting in delayed treatment. In this study, we examined 22 cases, among which only nine cases (40.9%) presented with the typical triad of symptoms. While 20 patients (90.9%) complained of local tenderness, three cases showed the sole symptom. Without imaging studies, these cases would not have been diagnosed and proper treatment would have been delayed. However, there is an ongoing debate on whether MRI or US should be the initial imaging modality to detect subungual tumors. In this study, high-resolution US showed similar sensitivity to 3.0-T MRI in detecting glomus tumors. They agreed on the mass size, with a gamma coefficient of 1 and a kappa coefficient of 0.771 ($p = 0.001$). In terms of the cost-effectiveness and clinical application, we suggest US as the primary imaging modality for suspected subungual glomus tumors.

Another objective of preoperative imaging studies is to identify the location of lesions in advance. Precisely locating small subungual tumors without imaging studies is extremely difficult, while improper localization may cause incomplete removal of the tumor, leading to its recurrence. MRI and US play a vital role in the preoperative localization of glomus tumors [9,10]. Most studies have reported their accuracy for tumor localization and size estimation [11,12], despite some studies with contrasting results [13].

The classic appearance of glomus tumors on MRI is low signal intensity on T1-weighted images, high signal intensity on T2-weighted images, and substantial enhancement on post-contrast images. However, these findings are not specific and may be seen in other solid hand tumors or cysts [14,15]. Post-gadolinium enhancement, fat saturation imaging, and magnetic resonance angiography may also be helpful in certain cases [16]. In addition to the high cost, limited specificity, and negative predictive value [14], multiple investigations [16,17]

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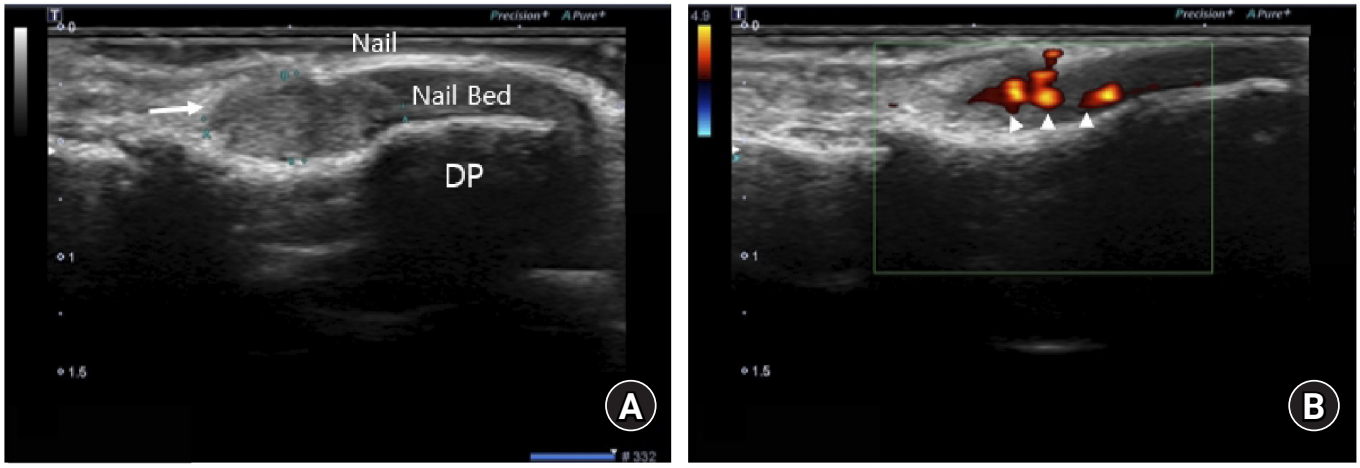

Fig. 2. Representative ultrasound images of a glomus tumor. (A) A solid, homogeneous isoechoic nodule (arrow) is seen beneath the nail. (B) A glomus tumor with marked hypervascularity (arrowheads) on power Doppler imaging. DP, distal phalanx.

have found that patients feel a lack of control and sense of vulnerability due to the unique and unfamiliar setting of an MRI scanner [18]. Therefore, some authors recommend performing MRI only in patients with atypical clinical presentations [19].

The common features of subungual glomus tumors on US include a small, solid, homogeneously isoechoic or hypoechoic, well-demarcated nodule beneath the nail, hypervascularity on color or power Doppler imaging, and bony erosion of the underlying phalangeal bone (Fig. 2) [20,21]. In our study, we defined glomus tumors as positive US findings of a subungual soft-tissue mass showing bony erosion or hypervascularity on Doppler imaging. Hypervascularity is possibly relevant to the pathology of glomus tumors as they comprise different proportions of glomus cells, vascular tissues, and smooth muscles. Different pathological types of glomus tumors have different types of internal blood flow [22].

Some studies have concluded that the characteristics of MRI and US for diagnosing subungual glomus tumors are not unique [14,15,22]. The radiological features of the cases in this study were also diverse. Therefore, we speculate that subungual tumors cannot be diagnosed based solely on MRI and US. The clinical symptoms must also be considered. Considering the cost, accessibility, and challenges of MRI, we believe that high-resolution US would be sufficient as a tool for imaging subungual glomus tumors along with clinical manifestations.

However, US also has disadvantages, such as being operator-dependent and requiring an experienced musculoskeletal sonographer. According to the literature [20] and our experience, locating and accurately diagnosing small subungual tumors using US is technically challenging. We should (1) use a high-frequency light probe, such as a Hockey stick probe with sufficient US transmission gel, (2) avoid the application of pressure during Doppler examination, (3) compare the images with those from the contralateral side, and (4) continuously probe from the dorsal side of the nail to the volar pulp side to avoid missing the rare case of multiple lesions.

The retrospective design and small sample size of this study limit its generalizability. The small sample size was due to the extremely low incidence of the disease and the small number of patients who underwent both imaging tests. Further studies that support these results with continuous data collection are necessary.

Conclusion

The results of this study showed that the detection rate of high-resolution US for subungual glomus tumors is as high as that of MRI. US can be applied easily and quickly and can be more useful as a primary diagnostic tool.

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Conflicts of interest

The authors have nothing to disclose.

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