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Original Article

The Efficacy of Magnetic Resonance Imaging for the Diagnosis of Superior Semicircular Canal Dehiscence

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OBJECTIVE: This study aimed to evaluate the efficacy of magnetic resonance imaging (MRI) for diagnosing superior semicircular canal dehiscence (SSCD).

MATERIALS and METHODS: The radiological records of patients who were admitted to our clinic with complaints of otologic and neuro-otologic symptoms between October 2014 and December 2015 were retrospectively reviewed. Among these patients, those who underwent both computed tomography and MRI and were reported to have SSCD in the temporal bone on at least one side were included in the study group. MRI records of patients with a confirmed diagnosis were then assessed for the presence of SSCD.

RESULTS: The left and right semicircular canals of 52 patients were evaluated in this study. The sensitivity and specificity of MRI in the diagnosis of SSCD was 89.06% and 90%, respectively. The positive and negative predictive values were 93.44% and 83.72%, respectively.

CONCLUSION: The use of multiplanar reformats and angulation techniques during MRI assessment of patients with neuro-otologic symptoms can improve the diagnostic process for patients with SSCD. This may allow early diagnosis of the disease by using just one imaging method, which would also reduce the costs per patient during the diagnosis period.

KEYWORDS: Superior semicircular canal dehiscence, magnetic resonance imaging, computed tomography, T2-weighted turbo spin echo

INTRODUCTION

Superior semicircular canal dehiscence syndrome is characterized by vestibular symptoms that occur as a result of sound or pressure changes. It was first described in 1998 by Minor et al. [1] The main reason for the emergence of symptoms is the thinning or lack of bony structure in the superior semicircular canal (SSC), which can be congenital, acquired, or both. Cadaveric studies showed severe thinning of SSC in 1.4% and SSCD in 0.5% of cases [2]. The superior semicircular canal dehiscence (SSCD) rate varies between 0.3% and 4.9% in radiological prevalence studies based on computed tomography data [3, 4].

Numerous research studies have been conducted with computed tomography (CT) to determine SSCD. By reformatting high-resolution CT sections of SSC with 0.5-1 mm intervals (in oblique planes such as those of Pöschl/Stenver), high rates of sensitivity and specificity were obtained. CT has been accepted as the gold standard for the diagnosis of SSCD [5-8].

Magnetic resonance imaging (MRI) is becoming more widespread in patients with neuro-otologic symptoms in recent years as a result of increased use of new sequences and higher resolution devices [9]. In general, MRI is the preferred imaging method for the evaluation of structures such as the brain stem and cranial nerves, whereas CT is used for identifying pathologies such as semicircular canal dehiscence in patients with neuro-otologic symptoms. This dual imaging modality for the diagnosis of patients delays the diagnosis course and increases the cost per patient. MRI is the more commonly used method in patients with neuro-otologic symptoms. Several studies have been conducted to evaluate the efficacy of MRI in diagnosing SSCD to avoid using both imaging modalities, and very high levels of specificity have been found [8, 10, 11].

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The aim of this study was to evaluate the efficacy of T2-weighted turbo spin echo magnetic resonance imaging for diagnosing SSCD and to compare the size of dehiscence between CT imaging and MRI.

MATERIALS and METHODS

Study Population

Local ethics committee approval was obtained at the beginning of the study (No: 2016/08). The radiological records of patients who presented between October 2014 and December 2015 were retrospectively reviewed. In total, 798 CT and 1705 MRI scans were performed during this period to evaluate the complaints of otologic and neuro-otologic symptoms. Among these patients, those who were reported to have at least one side of SSCD in the temporal bone CT and who had also undergone extra MRI scans were included in the study group. Each participant was informed and consent forms were obtained. SSCD diagnosis was confirmed after the evaluation of temporal CT images by two radiologists blinded to patient information. The MRI records of 52 patients whose diagnosis had been confirmed were also evaluated by these two blinded radiologists and evaluated for the presence or absence of SSCD.

Evaluation of CT Records

The records of high-resolution axial temporal CT scans obtained by 128 slice CT (SOMATOM Definition AS/AS Configuration, Germany) were evaluated. The slice thickness was 1 mm and imaging parameters were 120 kV, 220 mAs, 186x186 FOV. Data images were reconstructed at intervals of 0.75 mm and were evaluated using multiplanar reformatted images at a workstation (Syngo.via VA20 software, Siemens Healthcare, Forchheim, Germany). The semicircular canal bone rim was examined with images in the parallel (Pöschl), perpendicular (Stenver), and oblique sagittal planes to SSC. Localization was identified and the length of the bone defect parallel to the long axis of the canal was measured for the presence of dehiscence (Figure 1).

Evaluation of MRI Records

Imaging was performed using a 32-channel head coil and 1.5 T scanner (Siemens Magnetom Aera, Germany). Pre-contrast technical parameters were TR:400, TE: 8.6, FOV: 256X320, FoV phase: 100, thickness: 3 mm, nex: 1 for T1; TR:3820, TE: 96, FOV: 256X320, FoV phase: 100, thickness: 3 mm, nex: 2 for T2; and TR: 1000, TE: 266, FOV: 180X230, FoV phase: 80, thickness: 0.7 mm, nex: 1.4 for 3D Turbo spin echo T2 (t2 spc-tra-p2 iso-0.6), TR: 5.6 ms, TE: 2.49 ms, FOV: 235 mm, FoV phase: 81.3, thickness: 0.7 mm, nex: 1 for T2- CISS 3d axial. After 0.1 mmol/kg IV contrast injection TR: 400, TE: 8.6, FOV: 240X320, FOV phase: 100, thickness: 3 mm, nex: 3 for T1 axial, and TR: 471, TE: 12, FOV: 224X320, FOV phase: 100, thickness: 3 mm, nex: 3 for T1 coronal. T2- CISS 3d axial images were evaluated using multiplanar reformatted images at a workstation (Syngo.via VA20 software, Siemens Healthcare, Forchheim, Germany). Localization was identified and the length of the bone defect parallel to the long axis of the canal was measured for the presence of dehiscence. The presence of low signal intensity at the semicircular canal bone rim was evaluated with images in the parallel (Pöschl), perpendicular (Stenver), and oblique sagittal planes to SSC. The presence of low signal intensity at the semicircular canal bone rim was accepted as dehiscence and the length of the low signal intensity loss parallel to the long axis of the canal was accepted as the dehiscence length (Figure 2).

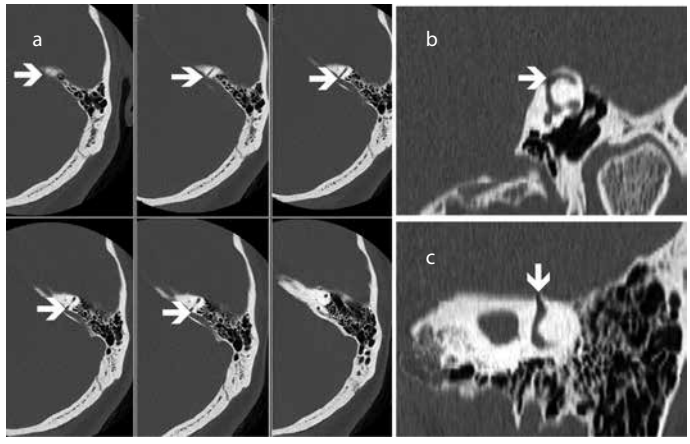

Figure 1. a-c. Left superior semicircular canal defect in a 50-year-old patient with complaints of vertigo: (a) Axial CT sections, (b) Reformatted image in the Pöschl plane, (c) Reformatted image in the Stenver plane (White arrow: Dehiscence)

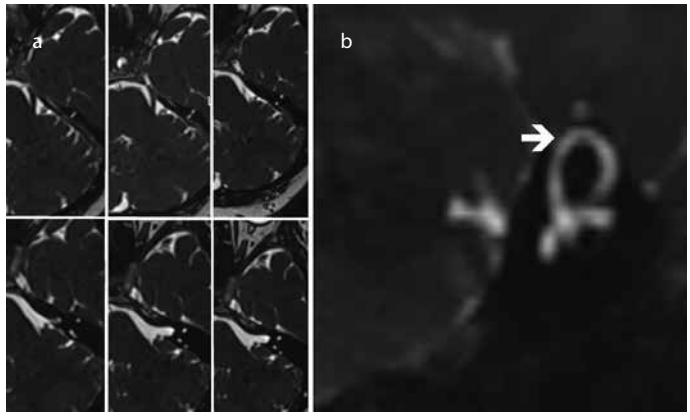

Figure 2. a, b. Left superior semicircular canal defect in a 50-year-old patient with complaints of vertigo: (a) T2-CISS MR image; (b) Reformatted image in the Poschl plane (White arrow: Dehiscence)

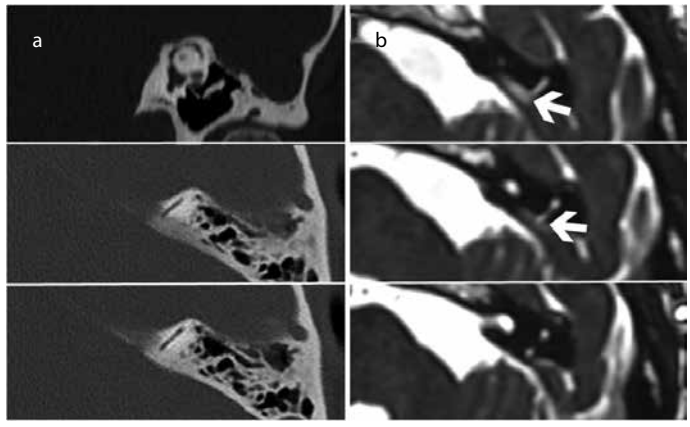

Figure 3. a, b. Imaging of the right superior semicircular canal (a) CT image showing abnormally thin bone layer (b) MRI image showing presence of a dehiscence (White arrow: Dehiscence)

Statistical Analysis

Data were analyzed with Statistical Package for Social Sciences version 15.0 for Windows (SPSS Inc.; Chicago, IL, USA). The presence or absence of an SSCD in CT imaging was accepted as the correct diagnosis. In addition to the sensitivity and specificity, positive and negative predictive values were calculated. The size of dehiscence was also compared with a t-test. A p-value of <0.05 was considered significantly different.

Table 1. Evaluation of the presence of SSCD on MRI compared with CT

	Dehiscence on CT	No dehiscence on CT
Dehiscence on MRI	57	4
No dehiscence on MRI	7	36

CT: computed tomography; MRI: magnetic resonance imaging

RESULTS

The left and right SSCs of 52 patients were evaluated in this study (a sample size of 104). There were 25 males (48%) and 27 females (52%). The mean age was 21.1±13.8 years (ranging from 18 to 83 years).

Defects were found in 64 (61.5%) SSCs at CT evaluation, which was accepted as the gold standard in the assessment. The defect was bilateral in 12 (23.1%) patients. In our temporal bone CT archive consisting of 1596 scans, the total defect rate in SSC was found to be 4%.

An evaluation of MRI compared with the CT results is summarized in Table 1. The sensitivity of MRI in the diagnosis of SSCD was 89.06% (95% CI, range: 78.57%-95.49%) and the specificity was 90.00% (95% CI, range: 76.34%-97.21%). The positive and negative predictive values in the study group were 93.44% (95% CI, 84.05%-98.18%) and 83.72% (95% CI, 69.30%-93.19%), respectively.

There were four cases whose CT results were normal but were reported to have SSCD on MRI (Figure 3). The CT images of these patients were re-evaluated. The bone thickness was 0.1 mm in two cases, 0.7 mm in one case, and 0.8 mm in one case.

Another parameter that we had evaluated in the study was the length of the SSC defect parallel to the long axis of the canal on CT and MRI. The average length of dehiscence in 57 SSCs with defects found on both CT and MRI was measured to be 2.1±1.1 mm (range: 0.7-4.8 mm) in CT evaluation and 2.4±1.1 mm (range: 1-6 mm) in MRI evaluation. When these two imaging methods were compared, the measured defect length was significantly higher when MRI evaluation was used ($p<0.01$).

DISCUSSION

Superior semicircular canal dehiscence is characterized by vestibular symptoms that occur as a result of sound or pressure changes. In severe cases it may lead to hearing loss. Numerous research studies have been conducted regarding the diagnosis and treatment of this condition in recent years, and while CT is the gold standard for diagnosis since these patients usually complain of neuro-otologic symptoms, MRI is often the preferred primary imaging technique due to better visualization of cranial nerves and the brainstem [2, 8, 9]. One of the most important goals of these imaging studies is to reduce the cost per patient of diagnosis and prevent delayed diagnosis by requiring multiple imaging modalities. The present study uses one of the largest data series to date to research the use of MRI in the diagnosis of SSCD.

In this study, the sensitivity of MRI for the diagnosis of SSCD was 89.06% and the specificity was 90.00%. To the best of our knowledge, the first similar study on this subject was reported by Krombach et al. [11] in 2004, who found that MRI had a sensitivity level of 96% and a specificity level of 98%. Subsequent studies showed similarly high sensitivity and specificity levels [8, 10].

Positive and negative predictive values are also important indicators for diagnostic tests. The positive predictive value for the use of MRI was 93.4% and the negative predictive value 83.7% in our study group. This positive predictive value was close to that found in similar studies in the literature [8, 10]; however, the negative predictive value of MRI was lower (33.3%) in a study published by Browaeys et al. [10]. That said, in a recent study presented by Spear et al., the negative predictive value was high (86.2%), like in our study [8].

There were four cases that showed dehiscence on MRI that were not confirmed with CT in our study. However, the bone thickness measured using CT images of these patients was found to be <1 mm. Clinical studies have shown that thinning of the bone can cause symptoms similar to SSCD [12].

Another important finding of our study was that when MRI was used for measuring the dehiscence size, significantly larger measurements were obtained than when CT images were used. There are few studies on this subject in the literature and where it has been investigated this effect has not been reported. Krombach et al. [11], for example, did not find a significant link between imaging modality and measurement of dehiscence size. In our study, the size of dehiscence was detected to be 0.4±0.2 mm greater on MRI than CT. We think this difference can be attributed to the different measured bone tissue mineralization and magnetic susceptibility. It is therefore important to consider this effect when reporting SSCD using MRI.

Although our study used one of the largest datasets of any investigation regarding the use of MRI in the diagnosis of SSCD, the small number of cases in the patient group and the use of SSC on the healthy side of patients with one-sided dehiscence as a negative control group were the main limitations of this study.

CONCLUSION

In the light of data we obtained, MRI has been shown to have high sensitivity and specificity in the diagnosis of SSCD, a clinical feature that should be considered in the differential diagnosis of patients with neuro-otologic symptoms. We believe that the use of multiplanar reformats and plane angulation techniques, which are not used in routine MRI assessment, can contribute to the improved diagnosis of patients with SSCD. This would increase the speed at which a patient can be diagnosed with SSCD since only one imaging method is required; it would also reduce the costs per patient during the diagnosis period.

Ethics Committee Approval: Ethics committee approval was received for this study from Recep Tayyip Erdoğan University Medical Faculty Local Ethics Committee (Approval No: 2016/08).

Informed Consent: Written informed consent was obtained from the patients who participated in this study.

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