Is MRI equal to CT in the evaluation of Thin and Dehiscent Superior Semicircular Canals?

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ABSTRACT

Objective: Can magnetic resonance imaging (MRI) diagnose abnormally thin and dehiscent superior semicircular canals (SSC) that traditionally rely on evaluation by computed tomography (CT) imaging?

Study Design: Retrospective Clinical Study

Setting: Tertiary referral center

Patients: Patients with a prior diagnosis of SSC dehiscence or vestibulocochlear symptoms who underwent both MRI and CT of the temporal bones over the past 3 years that included images of sufficient detail through the labyrinth, including fast imaging employing steady-state acquisition (FIESTA) T2 weighted coronal MRI.

Interventions: CT and MR images of SSC's were separately reviewed, in a blinded fashion by 3 neuroradiologists at our institution. CT diagnosis of abnormally thin or dehiscent SSC was used as the "gold" standard.
Main Outcome Measures: 1. Dehiscent SSC; 2. Abnormally thin SSC; 3. Normal SSC.

Results: 100 temporal bones with evaluable superior semicircular canals from 51 patients were eligible for review on CT and MR imaging. There were 26 cases of thin SSC and 17 cases of SSC dehiscence on CT imaging, of which 13 and 15 respectively were also found on MRI. There were 9 false positive dehiscent SSC cases and 4 thin SSC cases seen on MR imaging while not seen on CT. For thin SSC's, MRI sensitivity was 61.9% and specificity of 94.3% with a positive predictive value of 81.3% and negative predictive value of 86.2%. For dehiscent SSC's, sensitivity was 88.2% and specificity of 89.2% with a positive predictive value of 62.5% and a negative predictive value of 97.4%.

Conclusion: In this series, MRI in the axial and coronal plane had a high negative predicative value for thin SSC (86%) and dehiscent SSC (97%). However, MRI cannot conclusively diagnose thin or dehiscent SSC's. CT imaging is still necessary to confirm thin and dehiscent SSC's in some cases. The availability of 3-dimensional reconstruction on high resolution MRI and 3T strength MRI should be considered in future assessments of the potential role for MRI in SSC deficiency diagnosis.

INTRODUCTION

Patients with semicircular canal dehiscence (SSCD), initially described by Minor,[2] most commonly present with hearing loss, tinnitus and autophony as well as vestibular manifestations such as chronic disequilibrium, Tullio phenomenon, and Hennebert's sign.[10,11] Workup includes audiogram with tympanometry and acoustic reflexes as well as vestibular evoked myogenic potential (VEMP) thresholds, which are usually abnormally low in SSCD.[12]
The gold standard for diagnosis has been high resolution computed tomography (CT) with 0.5-1.0mm collimated scans[13] with projection into the plane of the superior semicircular canal[14] and additional reformations in the planes of Stenver and Poschl.[15,16] Stronger magnets and new techniques using thin-section T2-weighted imaging sequences on MRI have allowed for better evaluation of the middle and inner ear, such as the semicircular canals. In this study, we evaluate whether MRI can diagnose abnormally thin and dehiscent superior semicircular canals that traditionally rely on evaluation by CT imaging.

METHODS AND MATERIALS

This retrospective review was completed of adult patients at our institution of patients with either a prior diagnosis of SSC dehiscence or vestibulocochlear symptoms who underwent both MRI and high resolution multi-planar CT of the temporal bones over the past 3 years that included images of sufficient detail through the labyrinth, including FIESTA T2 weighted coronal MRI on a 1.5T or 3T MRI machine. Patients were excluded if there were any signs of involvement of the semicircular canals from prior surgery, tumors or other congenital abnormalities of the temporal bone.

From these patients, a secure database was populated including patients both with and without SSCD. Using CT as the reference "gold" standard to evaluate the MRI results, the MRI and CT images of these patients were reviewed in a blinded manner at separate times by 3 neuroradiologists at our institution.
The semicircular canals in each ear of each patient reviewed, whether CT or MRI, were given a diagnosis of one of 3 outcomes:

1. Superior semicircular canal (SSC) dehiscence;
2. Abnormally thin SSC;
3. Normal SSC.

The criteria for a diagnosis of abnormally thin SSC was < or =0.1mm of bone over the SSC and the general impression of the neuroradiologist. A final diagnosis/result for each temporal bone SSC reviewed was based on two-thirds majority agreement between the 3 neuroradiologists.

These results were placed within the database to allow for the determination of MRI sensitivity, specificity, positive predictive value and negative predictive value in patients with dehiscent SSC's as compared with CT with standard statistical analysis.

RESULTS

SSC's (100 canals)	Dehiscent on CT	Thin on CT	Normal on CT
Dehiscent on MRI	15	5	4
Thin on MRI	1	13	3
Normal on MRI	1	8	50

Table 1. CT & MRI detection of thin and dehiscent superior semicircular canals

SSC's (74 canals)	Thin on CT	Normal on CT
Thin on MRI	13	3
Normal on MRI	8	50

Sensitivity: 61.9% (CI 95%, 38.7%-81%) PPV: 81.3% (CI 95%, 53.7%-95%)
Specificity: 94.3% (CI 95%, 83.4%-98.5%) NPV: 86.2% (CI 95%, 74.1%-93.4%)

Table 2. CT & MRI detection of only thin superior semicircular canals (excluding dehiscent SSC's)

SSC's (100 canals)	Dehiscence on CT	No Dehiscence on CT
Dehiscence on MRI	15	9
No Dehiscence on MRI	2	74

Sensitivity: 88.2% (CI 95%, 62.3%-97.9%) PPV: 62.5% (CI 95%, 40.8%-80.4%)
Specificity: 89.2% (CI 95%, 79.9%-94.6%) NPV: 97.4% (CI 95%, 90%-99.5%)

Table 3. CT & MRI detection of only dehiscent superior semicircular canals

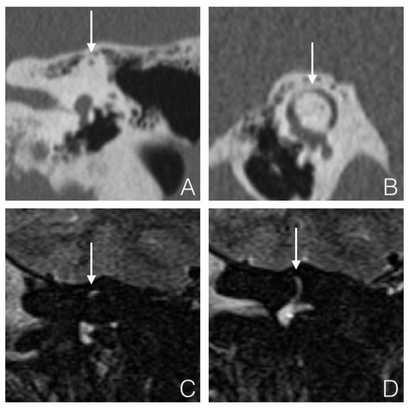

Figure 1. A patient with a normal left ear without evidence of dehiscent or thin superior SSC. CT images of the left superior SSC in the coronal view (A) and long-axis plane (B). T-2 Fiesta MRI of the left superior SSC in the coronal views (A & B).

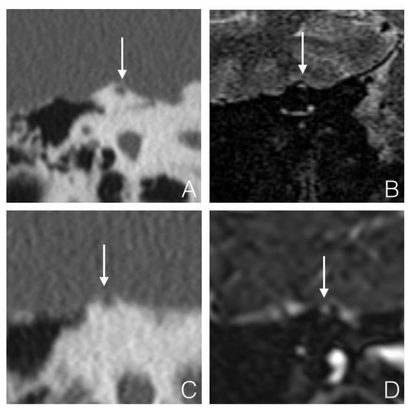

Figure 2. Coronal views of a right superior SSC considered thin on CT (A) and T-2 Fiesta MRI (B) showing a thin layer of bone over the superior SSC's. Coronal views from a different patient show a right SSCD on CT (C) and MRI (D) with an absence of bone over the SSC's.

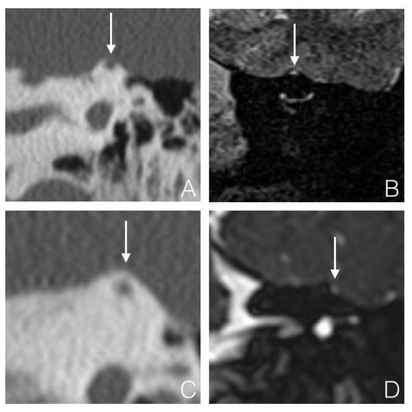

Figure 3. Coronal views of a patient's left superior SSC considered dehiscent on CT (A) and thin on MRI (B). Coronal views of a different patient's left superior SSC considered normal on CT (C) and dehiscent on MRI (D).

DISCUSSION

In our series, of the 17 cases of SSC dehiscence on CT images, only 15 were found on MRI giving a sensitivity of 88.2% with one considered thin and the other considered normal. Among cases of thin SSC, there were 26 cases found on CT images, of which 13 were also found on MRI with a sensitivity of 61.9%. While there was good resolution of the superior SSC among the T2 weighted FIESTA images in this series, we were limited to images in the coronal plane and did not have the advantage of examining the semicircular canals along their long and short-axis as we can on the high resolution CT.
Our MRI IAC protocol does not include these multi-planar reconstructions, which would have likely identified the 2 cases of SSCD not identified on MRI in our series. Given this limitation and lack of multi-planar reconstructions of the SSC's, a negative or normal MRI finding cannot effectively rule out a thin or dehiscent SSC in our series.
While there is sufficient detail and it is clear in many cases on MRI T2 weighted coronal imaging that there is no evidence of a thin or dehiscent SSC as in Figure 1, CT imaging should still be required to confirm dehiscence cases where the SSC appears thin or dehiscent on MRI as in Figure 2. Dedicated use of a 3T MRI may also be important as it has been noted that very thin bony coverage may be more obvious on 3T FIESTA.[7]

CONCLUSIONS

In this series, MRI in the axial and coronal plane had a high negative predicative value for thin SSC (86.2%) and dehiscent SSC (97.4%). However, MRI cannot conclusively diagnose thin or dehiscent SSC's. CT imaging is still necessary to confirm thin and dehiscent SSC's in some cases. The availability of 3-dimensional reconstruction on high resolution MRI and 3T strength MRI should be considered in future assessments of the potential role for MRI in SSC deficiency diagnosis.

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