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Using temporal bone computed tomography to predict sensorineural hearing loss in otic capsule-sparing temporal bone fracture

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ABSTRACT

Objectives: The purpose of this study was to investigate the efficacy of otic capsule-sparing (OCS) length for the prediction of sensorineural hearing loss (SNHL) in patients with OCS temporal bone fracture.
Methods: Thirty-four patients with OCS temporal bone fracture were enrolled, and their temporal bone computed tomography (TBCT), audiogram, and medical records were reviewed. The TBCT measured the shortest length between the otic capsule and fracture line. This length was referred to as the OCS length and was used to predict SNHL. Ossicular dislocation and fracture were also evaluated. Patients were divided into two groups according to the presence of SNHL. Univariate and multivariate analyses were performed for age, gender, brain hemorrhage, mean bone conduction threshold on the contralesional side, OCS length, and ossicular dislocation and fracture on TBCT. A receiver operating characteristic (ROC) curve was produced to evaluate the efficacy of OCS length for the prediction of SNHL. To determine an association between degree of SNHL and OCS length, regression analysis was conducted in the SNHL group.
Results: The mean OCS lengths of the SNHL and non-SNHL groups were 4.42 ± 1.67 mm and 8.00 ± 5.71 mm, respectively. In the univariate analysis, a relatively significant association ($P < 0.20$) was found between SNHL and age, brain hemorrhage, mean bone conduction threshold on the contralesional side, OCS length, and incus dislocation. Multivariate analysis was performed using these factors. On multivariate analysis, OCS length ($P = 0.030$, odds ratio = 0.598; 95% confidence interval 0.375–0.952) was the only independent factor associated with SNHL. The area under the curve (AUC) was 0.747. When the cut-off value of OCS length was 5.27 mm, the sensitivity and specificity for the prediction of SNHL were 71.4% and 69.2%, respectively. In the regression analysis, OCS length showed a significant association with degree of SNHL in the SNHL group ($P = 0.025$, β=-12.822, SE = 5.282).
Conclusions: The major finding of our study was that OCS length was significantly associated with SNHL in patients with OCS temporal bone fracture. Such patients with a short OCS length had a higher likelihood of SNHL.

Introduction

Traumatic head injury is a particularly common trauma. According to data from the United States Centers for Disease Control and Prevention, 1.7 million traumatic head injuries occur in the United States each year [1]. Approximately 4% of patients treated for head trauma experience skull fracture, and 14–22% of skull fracture patients have a temporal bone fracture [2,3]. As the temporal bone protects the critical structures, a number of complications can occur concurrent with temporal bone fracture. Frequent complications include sensorineural hearing loss (SNHL), conductive hearing loss, cerebrospinal fluid leakage, and facial nerve palsy [3–5]. According to the literature, the rate of SNHL induced by temporal bone fracture is reported to be 0–14% [6]. Moreover, as steroid therapy may be helpful in patients with SNHL [7], the diagnosis of SNHL is important. However, many patients with temporal bone fracture also experience brain injury [7], which interferes with the hearing test. Thus, the tools used to diagnose SNHL in unconscious patients can contribute to the management of temporal bone fracture.

Temporal bone computed tomography (TBCT) is the basic test used for the diagnosis of temporal bone fracture. It can be performed

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regardless of the level of consciousness of a patient and offers objective information regarding the status of a temporal bone fracture. According to TBCT results, temporal bone fracture can be divided into two types: otic capsule-disrupting (OCD) and otic capsule-sparing (OCS) fractures. Only 2.5–5.8% of temporal bone fractures disrupt the otic capsule [4,8], and OCS fractures are much more frequent than OCD fractures. As the otic capsule is the bony structure that contains inner ear structures, such as the cochlea and semicircular canals, OCD fractures almost always result in SNHL [9,10]. OCS fractures are also combined with SNHL [11]. However, in OCS fractures, there is a lack of TBCT-based criteria for the prediction of SNHL, although it has been reported that patients with incus dislocation have a higher possibility of incurring SNHL [11]. Therefore, development of a set of criteria that use TBCT to predict SNHL in patients with OCS fractures can contribute to the management of temporal bone fracture. In the present study, we measured the shortest length between the otic capsule and fracture line on TBCT and investigated whether SNHL could be predicted using this parameter.

Methods

Subjects

This retrospective study was approved by the Institutional Review Board of our medical center (IRB No. 1702-011-16044). The inclusion criteria were as follows: 1) patients were diagnosed with OCS fracture based on TBCT between January 2012 and December 2016; 2) patients had audiometric data; and 3) patients complained of unilateral hearing loss on the ipsilesional side. Forty-one patients were included, and their TBCT, audiogram, and medical records were reviewed. Of the 41 patients with OCS temporal bone fracture, 7 patients underwent pure tone audiometry more than 2 weeks after experiencing a head trauma and were excluded from the study. In total, 34 patients (82.9%) were finally enrolled. The patients comprised 25 men and 9 women, with a mean age of 48.2 ± 18.4 years. No patient complained of asymmetric hearing loss or ear disease prior to the trauma.

Radiologic evaluation

Patients underwent TBCT within 4 days after head trauma. All TBCT images were obtained using a 256-slice multiple detector CT scanner (Brilliance iCT; Philips Healthcare, Eindhoven, Netherlands) with a slice thickness of 1 mm. A single radiologist evaluated the TBCT images and diagnosed whether the patient had an OCS fracture. The shortest length between the otic capsule bone and fracture line was measured. This length was referred to as the "OCS length" and was used to predict SNHL (Fig. 1). Ossicular dislocation and fracture were also evaluated.

Audiometric evaluation

Pure tone audiometry was performed within 2 weeks of head trauma and was used to determine the hearing level of each patient. Pure tone thresholds (dB HL) for air conduction and bone conduction were recorded at 0.25, 0.5, 1, 2, 3, and 4 kHz. The bone conduction threshold on the contralesional side was regarded as the bone conduction threshold on the ipsilesional side prior to temporal bone fracture based on the following two assumptions: 1) the bone conduction thresholds on both sides were the same before temporal bone fracture; and 2) the bone conduction threshold on the contralesional side was unchanged after temporal bone fracture. SNHL was diagnosed based on the difference in bone conduction thresholds at the same frequency between the ipsilesional and contralesional sides. SNHL was identified when this difference was greater than 15 dB HL for at least one of these frequencies. Based on the results, patients were divided into two groups: SNHL and non-SNHL. The sum of these differences at all frequencies was referred to as the "degree of SNHL". When the difference was less than zero, it was regarded as zero. The contralesional mean bone conduction threshold at all frequencies was calculated to estimate the ipsilesional bone conduction threshold prior to temporal bone fracture.

Statistical analysis

Univariate analysis was used to identify factors with a relatively significant association ($P < 0.20$) with SNHL. Multivariate logistic regression analysis was then performed using these variables. The association between given factors of interest and SNHL was determined based on the odds ratio (OR). If the OR was equal to 1, no association was noted. If the OR was higher (or lower) than 1, the associated factor was considered to be related to a higher (or lower) possibility of SNHL. A receiver operating characteristic (ROC) curve was created with the associated factors, and an area under the curve (AUC) was obtained to evaluate the efficacy of the prediction of SNHL. To determine an association between degree of SNHL and OCS length, regression analysis was conducted in the SNHL group. A *P*-value less than 0.05 was used to indicate statistical significance. The IBM SPSS ver. 23.0 software package (IBM Corp., Armonk, NY, USA) was used for the analyses.

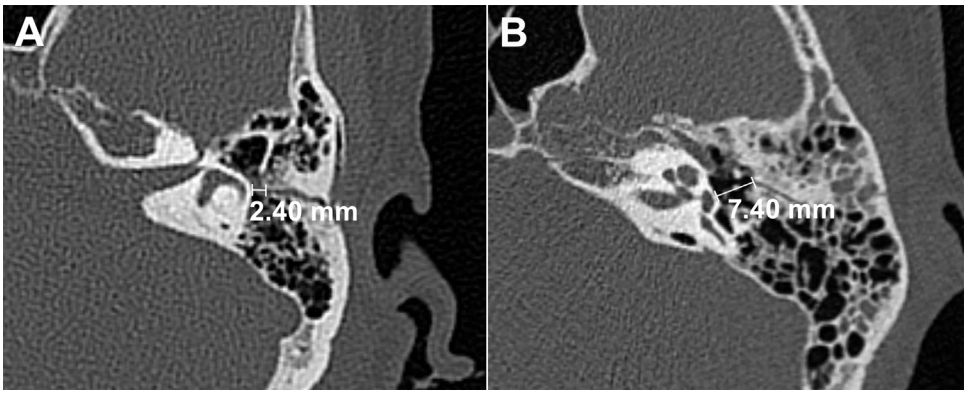

Fig. 1. Prediction of SNHL in OCS temporal bone fracture using OCS length. (A) A 64-year-old woman with an OCS fracture. The OCS length was 2.40 mm. SNHL was present at 1, 2, 3 and 4 kHz. (B) A 23-year-old man with an OCS fracture. The OCS length was 7.40 mm. This patient had no SNHL. OCS, otic capsule-sparing; SNHL, sensorineural hearing loss.

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