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Pediatric central auditory processing disorder showing elevated threshold on pure tone audiogram

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ABSTRACT

Central auditory processing disorder (CAPD) is a condition in which dysfunction in the central auditory system causes difficulty in listening to conversations, particularly under noisy conditions, despite normal peripheral auditory function. Central auditory testing is generally performed in patients with normal hearing on the pure tone audiogram (PTA). This report shows that diagnosis of CAPD is possible even in the presence of an elevated threshold on the PTA, provided that the normal function of the peripheral auditory pathway was verified by distortion product otoacoustic emission (DPOAE), auditory brainstem response (ABR), and auditory steady state response (ASSR). Three pediatric cases (9- and 10-year-old girls and an 8-year-old boy) of CAPD with elevated thresholds on PTAs are presented. The chief complaint was difficulty in listening to conversations. PTA showed elevated thresholds, but the responses and thresholds for DPOAE, ABR, and ASSR were normal, showing that peripheral auditory function was normal. Significant findings of central auditory testing such as dichotic speech tests, time compression of speech signals, and binaural interaction tests confirmed the diagnosis of CAPD. These threshold shifts in PTA may provide a new concept of a clinical symptom due to central auditory dysfunction in CAPD.

1. Introduction

Central auditory processing disorder (CAPD) is a condition in which dysfunction in the central auditory system causes difficulty in conversation, listening under noisy conditions, and sound localization, despite normal peripheral auditory function. Subjects with CAPD experience auditory impairment, communication impairment, or both. Dysfunction in the central auditory system is documented by central auditory testing, including dichotic speech tests, time compression of speech signals, binaural interaction tests, and gap detection tests [1,2].

The subjective auditory symptoms and findings in central auditory testing in CAPD are diverse and heterogeneous. The etiology of CAPD ranges from neuromorphological disorders (ectopic cerebral cortex areas and polymicrogyri) and neuromaturational delay to other neurological disease or insults. Generally, subjects with normal hearing on the pure tone audiogram (PTA) are assessed by central auditory testing, in order to verify the reliability of these tests for central auditory function using stimuli delivered via the peripheral auditory system. The American Academy of Audiology (AAA) Clinical Practice Guideline for CAPD, however, does not provide definitive criteria regarding the threshold shift in PTA in patients with CAPD [2]. We present three cases of pediatric

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CAPD associated with elevated thresholds in PTA. The relationship of the diagnoses of CAPD and functional hearing loss (FHL) is discussed, as an informative example of the current understanding and diagnosis of CAPD in children.

2. Case presentation

2.1. Case 1

A 9-year-old girl was referred to our Otolaryngology Department with complaints of difficulty with conversation in noisy surroundings and in listening to music. She had been assessed by a pediatric neuropsychiatrist because of subjective complaints of blurred vision. Ophthalmologic inspections, electroencephalography, and brain magnetic resonance imaging (MRI) detected no abnormality and she was diagnosed with high-functioning pervasive developmental disorder (HFPDD). In the preschool period, she had shown tendency to be hyperactive, but no developmental delay in language or sensorimotor ability had been noted. At the age of 9-year-old, Full-scale IQ (FSIQ), Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI), and Processing Speed Index (PSI) were 110, 109, 109, 94, and 115 on the Wechsler Intelligence Scale for Children-IV (WISC-IV), respectively. FSIQ was within the normal range for her age, but WMI was relatively low compared with standard scores for the other indexes. Otoscopic examination showed normal results. A pure tone audiogram (PTA) showed bilateral moderate-to-severe hearing loss, predominantly in the low frequencies (Fig. 1A), but responses in distortion-product otoacoustic emissions (DPOAEs) were bilaterally intact (Fig. 1C). Thresholds in auditory steady state response (ASSR) were normal, including those in the low frequencies (Fig. 1B). As the peripheral auditory pathways were shown to be functioning normally, further central auditory testing was performed. For central auditory testing, auditory stimuli were presented via headphones at 40 dB nHL by default. Loudness was manually adjusted to the most comfortable level for the subject. For dichotic listening, forty monosyllable stimuli were presented to both ears, and laterality index was calculated as follows: (number of monosyllable stimuli with correct perception by the right ear − correct perception by the left ear)/(correct perception by the right ear + correct perception by the left ear) × 100. For time compression of speech signals, Japanese words with 90–10% time compression rate were presented with 10% decrement (3 stimuli for each compression rate). When 2 out of the 3 stimuli were correctly detected, the subject was considered to be able to respond correctly to speech signals with time compression. For gap detection test (gaps-in-noise test), the patient's ability to detect gaps with duration of

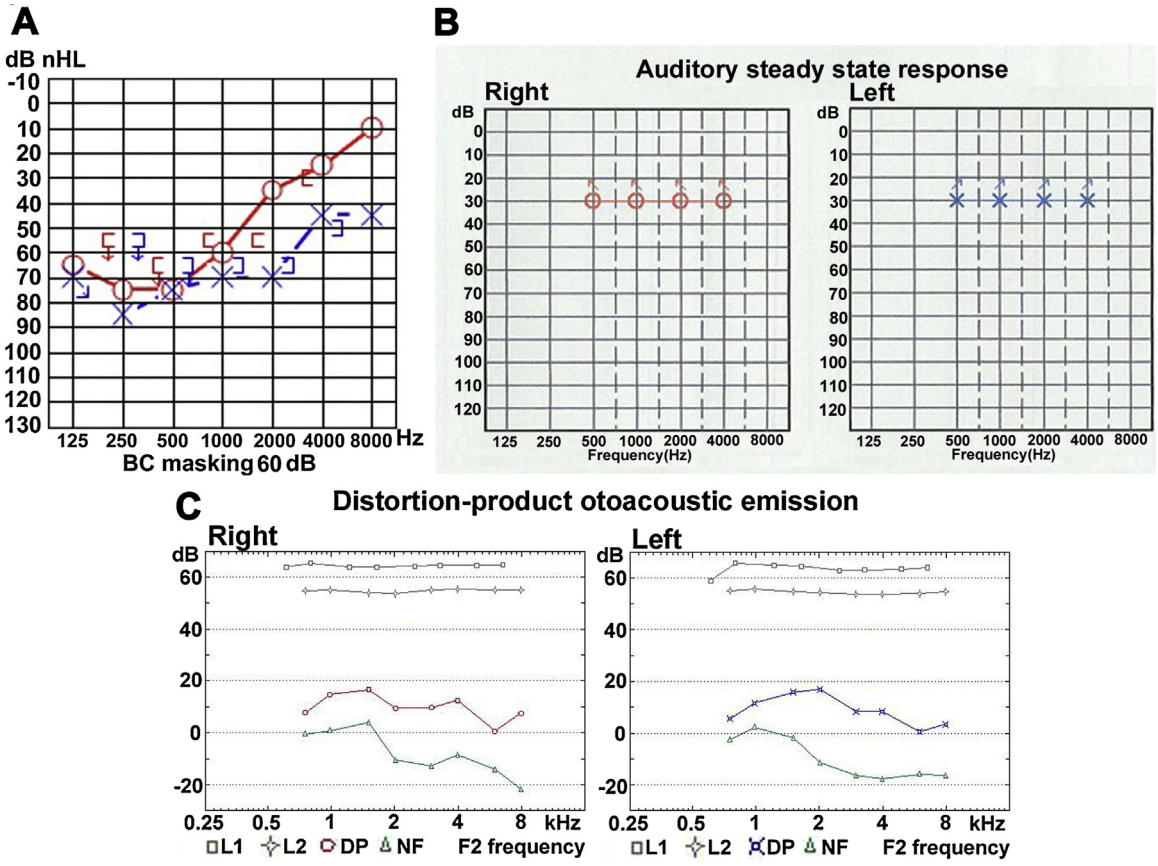

Fig. 1. Audiological profile of Case 1. Pure tone audiogram shows bilateral, moderate-to-severely elevated thresholds, predominantly in the low frequencies (A). Thresholds of auditory steady state response are normal (right, 30 dB; left, 30 dB) (B). Responses of distortion-product otoacoustic emissions (DPOAEs) are normal across all frequencies (C). In the figures of DPOAEs, the lower line (green line) indicates background noise level and the upper line (red or blue line) indicates DPOAE response levels. The *x*-axis represents F2 frequency.