Long-term Follow-up of Menière's Disease in Children

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Abstract
A retrospective critical analysis of our epidemiological data regarding paediatric patients with Menière's Disease (MD) at initial diagnosis was conducted, in the light of long-term follow-up and comparison with available data in the literature. A series of 472 children had access to ENT Department of ASST Spedali Civili of Brescia, Italy for balance disorders. They underwent history investigation and complete audiological and vestibular assessment. In 4 cases, a MD was diagnosed and they were submitted to careful and long-term follow-up (5-14 years), with periodic clinical testing and telephone survey after recovery. Only one of our 4 patients initially diagnosed as MD has been confirmed as effective MD over years. In the other 3 cases, other pathologies subsequently emerged, which denied the initial diagnosis of MD. In addition, no patients were diagnosed as definitive MD under the age of 13.MD in childhood should be considered extremely rare at first diagnosis (0.2% of cases in our series), and a definitive diagnosis is only possible after years of careful follow up, especially in case of pre-adolescent MD-like symptoms.

Keywords: *Paediatric Menière Disease, Menière Children, Meniere Childhood, Endolymphatic hydrops children, Menière Paediatrics.*

Abbreviations
AAO-HNS – American Academy of Otolaryngology–Head and Neck Surgery
ABR – Auditory Brainstem Responses
AS – Anti-compensatory saccades
AUVL – Acute Unilateral Vestibular Loss
BPVC – Benign Paroxysmal Vertigo of Childhood
cVEMPs – Cervical Vestibular-Evoked Myogenic Potentials
CT – Computerized Tomography
ECG – Electrocardiogram
EEG – Electroencephalogram
EVAS – Enlarged Vestibular Aqueduct Syndrome
HIMP – Head Impulse Paradigm
MD – Menière's Disease
MMD – Menière's Disease and migraine
MRI – Magnetic Resonance Imaging
NPI – Neuropsychiatric Evaluation
oVEMPs – Ocular Vestibular-Evoked Myogenic Potentials
PTA – Pure Tone Audiometry
RCT – Rotatory Chair Test
SHIMP – Suppression Head Impulse Paradigm
VCS – Vestibular Caloric Stimulation
VEMPs – Vestibular-Evoked Myogenic Potentials
vHIT – Video Head Impulse Test
VM – Vestibular Migraine
VOR – Vestibulo-Ocular Reflex

Introduction

Approximately 5–10% of children experience vertigo (Balzanelli et al., 2021; Davitt et al., 2020). Published epidemiological data on the prevalence of Menière's Disease (MD) in children, range from 0.1 to 7% of cases, and are highest between 10 and

19 years of age (Table 1) (Balzanelli et al., 2021; Brain et al., 1938; Green et al., 1951; Cawthorne et al., 1954; Golding-Wood et al., 1960; Harrison et al., 1962; Thomas et al., 1971; Stahle et al., 1978; Meyerhoff et al., 1978; Mizukoshi et al., 1979; Pfaltz et al., 1981; Kitahara et al., 1981; Filipo et al., 1985; Yanagida et al., 1986; Hausler et al., 1987; Mizukoshi et al., 2001; Akagi et al., 2001; Choung et al., 2006; Wang et al., 2018; Wiener-Vacher et al., 2018; Brodsky et al., 2020; Wang et al., 2021). To date, the information available in the literature on this topic is relatively limited and consists largely of case reports and case series (Swain et al., 2022). To the best of our knowledge, this is the first long-term retrospective work on paediatric MD, as a few published reports are based only on small sample case series.

More common paediatric conditions are described in almost all studies, and include Vestibular Migraine -VM (23.8%), Benign Paroxysmal Vertigo of Childhood - BPVC (13.7%), unidentified causes (11.7%), and Acute Unilateral Vestibular Loss - AUVL (8.47%), as well as other less frequent causes (Balzanelli et al., 2021; Davitt et al., 2020).

The 2015 guidelines of the American Academy of Otolaryngology–Head and Neck Surgery (AAO-HNS) for the diagnosis of MD require the presence in the clinical history of symptoms and complex concepts such as vertigo, fluctuation, fullness, and tinnitus, in both definite and probable forms (Lopez-Escamez et al., 2015).

In addition, the prevalence of balance disorders in childhood may therefore be underestimated, especially in younger age groups, due to the children's limited communication and descriptive skills, as well as fear-related factors that do not allow them to recognize their "dizzy" disorder (Balzanelli et al., 2021).

There are, in fact, several classifications of MD that do not distinguish between adult and paediatric forms: some authors suggested simplifying the diagnostic criteria for younger children by limiting them to the presence of fluctuating low-frequency hearing loss together with spontaneous attacks of idiopathic vertigo (Brantberg et al., 2012; Casani et al., 2015). Others are based on clinical–etiological criteria, proposed by Schuknecht in 1982 and Paparella et al. in 1990 (Schuknect et al., 1983; Paparella et al., 1990). Currently, the Bárány Society Classification of MD proposed in 2015 is the most widely accepted in the field of clinical, epidemiological and statistical scientific research (Definite and Probable MD, focused on the number and duration of episodes, symptoms and their fluctuation, with instrumental confirmation of the cochlear component) (Lopez-Escamez et al., 2015). More recently, Frejo et al. in 2016-2017 proposed a classification in a more articulated format, aimed to categorize the heterogeneous MD presentations into multiple subgroups of patients (based on mono/bilaterality, family history, autoimmunity, and migraine) (Frejo et al., 2016; Frejo et al., 2017).

In parallel, advances in imaging have led to additional classifications based solely on radiologic assessment of the degree of hydrops, such as that proposed by Attyé in 2017, or others that evaluate the extent of residual vestibular function and cochlear loss (Sobhy et al., 2019), but this is difficult to apply in children.

By published reports, we know that endolymphatic hydrops is defined by histological and/or radiological feature of MD (primary hydrops); however, it is not exclusive to this condition. It may also be found following acquired damage due to infections, such as labyrinthitis and meningitis, otitis, head trauma, otologic surgery, noise-induced hearing loss, schwannomas (secondary hydrops), delayed hydrops (also classified as a form of secondary hydrops), or embryological malformations (Mondini dysplasia and enlarged vestibular aqueduct syndrome – EVAS (both symptomatic and asymptomatic), as well as asymptomatic patients (Schuknecht et al., 1983; Gürkov et al., 2016). All these conditions, however, have never been described in children and we will not consider further speculation on the diagnosis and aetiopathology of MD in

children, as it is not the main topic of our work.

From an etiopathogenetic point of view, the endolymphatic hydrops remains the final common mechanism, but MD continues to be classified as a multifactorial and idiopathic disease (Oberman et al., 2017). Similarly to adults, in children a sequence of abnormalities has been identified in instrumental tests (PTA, cVEMPs, oVEMPs, caloric tests, vHIT), showing a significantly decreasing frequency proceeding from the cochlea toward the saccule, utricle, and semicircular canals. The similarity found in the pattern of progressive involvement of the inner ear structures—radiologically, histologically, and instrumentally—may indicate the same pathogenetic mechanism (Wang et al., 2018), but the fact that the younger is the age of the child, and the rarer or absent is the diagnosis of definite MD, suggests possible concomitant aetiopathogenetic factors (hormonal, cognitive or neuro-developmental) (Stenberg et al., 2001; Andrews et al., 1992; Price et al., 1994; Grillo et al., 2021; Caruso et al., 2021; Jian et al., 2019).

In any case, paediatric MD is to be considered a rare entity, and its prevalence under 10 years of age is only slightly above zero, according to a few published case series (Brain et al., 1938; Green et al., 1951; Cawthorne et al., 1954; Golding-Wood et al., 1960; Harrison et al., 1962; Thomas et al., 1971; Mizukoshi et al., 1979; Pfaltz et al., 1981; Kitahara et al., 1981; Mizukoshi et al., 2001). Our long-term follow-up study fully agrees with this finding.

Methods

The study was observational, retrospective, and non-profit, with the objective of identifying the prevalence and the long-term effective diagnosis of MD in a sample of 472 paediatric patients <18 years of age with balance disorders who had access to our Clinic between 2010 and 2019. The patient cohort was obtained through an analysis of the available clinical documentation (electronic and paper medical records) (Balzanelli et al., 2021).

For the diagnosis of symptoms suggesting MD, we referred to the AAO-HNS guidelines from 1995, revised in 2015 (Lopez-Escamez et al., 2015).

Patients with symptoms unrelated to vertigo, patients without hearing loss, individuals examined for reasons other than vertigo and hearing impairment, and patients not accompanied by parents, relatives, or legal guardians were excluded.

The database includes all clinical data regarding age at the first visit, type and number of vertigo episodes, associated symptoms (nausea/vomiting, hearing loss, fullness, headache), family history of migraine vertigo, motion sickness, and general health problems, up to additional specialist or diagnostic tests. All patients undergone a long-term follow-up: the minimum was 5 years, up to 14 years (June 30, 2019 to June 30, 2024).

All children underwent otoscopy and audiological evaluation with pure-tone audiometry and tympanometry. The bedside assessment of vestibular function was performed by means of infrared video-nystagmoscopy (Synapsis Nystalab—Frenzel wireless video system), and included:

- Ocular movements (horizontal and vertical convergence, saccades, smooth pursuit, fixation);
- Spontaneous nystagmus;
- Positional nystagmus (supine/Rose position, right and left lateral positions);
- Positioning nystagmus (Dix–Hallpike and supine roll test maneuver);
- Evoked nystagmus (Head Shaking Test and Head Impulse Test).

Vestibulo-spinal reflexes were evaluated using the Romberg test, Unterberger-Fukuda test, and outstretched-arms test.

When the bedside vestibular evaluation was negative, the rotatory chair test (RCT) was performed; from 2013 onward, patients underwent mainly the vestibular high frequency stimulation by means of the video head impulse test (vHIT) (Natus-Otometrics, Godtrup, Denmark) to assess vestibu-

lo-ocular reflex (VOR) amplitude, including the conventional head impulse paradigm (HIMP), the suppression head impulse paradigm (SHIMP), the compensatory and anti-compensatory saccades. This is an "easy-to-use", quick, sensitive and non-invasive test, always accepted by the young patient and with a very low range of false positives or false negatives.

No patient underwent Vestibular Caloric Stimulation – VCS, due to its invasiveness and poor tolerability. No patient underwent Vestibular-Evoked Myogenic Potentials – VEMPs, due to the high level of movement artifacts and low electrode impedance of our technological equipment. When clinical and/or instrumental vestibular tests were inconclusive, the children underwent an in-depth interview with their parents and a child neuropsychiatric evaluation to analyse neurodevelopmental level and to exclude sensory–motor deficits. Depending on the neurological outcome or in cases of still inconclusive results, further diagnostic investigations were performed, including Auditory Brainstem Responses (ABR), Electroencephalogram (EEG), Computerized Tomography (CT) and Magnetic Resonance Imaging (MRI) of the brain, Electrocardiogram (ECG), or neuropsychiatric, ophthalmologic, orthopaedic, cardiologic, dental evaluations, etc.

All patients underwent regular audiological and vestibular examinations until functional recovery was achieved. Subsequently, a telephone survey was conducted with a follow-up of at least 5 years in the most recently diagnosed cases, up to 14 years in the first enrolled patients.

The study was approved by the Ethics Committee of ASST Spedali Civili of Brescia (protocol number 83787, 2019). Written informed consent was obtained from the parents of each participant.

Description of clinical cases

Case 1 – A.L., female

She presented in 2013 at the age of 5, with recurrent episodes of vertigo associated with fullness and tinnitus. Her family history was positive for migraine with headache, motion sickness and photophobia (mother).

Her pure-tone audiometry showed a mild right-sided hearing loss (< 40 dB) in the low and mid frequencies, fluctuating according to the perceived intensity of tinnitus.

The vestibular assessment revealed horizontal geotropic nystagmus in the left lateral decubitus position, a positive vibratory test with nystagmus to the left, and rightward rotation on the Unterberger test.

At the second visit one year later, she still reported right-sided fullness and vertigo, with evidence of left posterior semicircular canal BPPV. The video HIT was normal. She also reported new-onset headache (2 episodes).

One year later, the headache becomes frequent and disabling, she received a diagnosis of migraine in a specialized Headache Center, and her vertiginous symptoms manifested more as imbalance, not vertigo.

Three years later, she experienced a second paroxysmal vertigo episode, again on the left side.

At the last evaluation in 2023 and at the telephone survey in June 2024 (11 years follow-up), she reported only migraine headache, without further vertigo, imbalance, or cochlear symptoms.

Case 2 – S.P., female

She presented in 2015 at age of 13 years, with recurrent episodes of vertigo associated with left-sided fullness and tinnitus. She never reported headache before and had no family history of either Ménière's disease or migraine.

At the first evaluation, both pure-tone audiometry and vestibular assessment with vHIT were normal.

After 3 months, the pure-tone audiometry showed a mild left-sided hearing loss (25 dB) in low frequencies (250–500 Hz), while the vestibular symptoms persisted unchanged.

A subsequent evaluation a few months later, showed more intense vertigo and nausea episodes; the vestibular assess-

ment revealed horizontal geotropic nystagmus in the right lateral decubitus position.

Repeated evaluations in the following years confirmed the suspicion of Menière's disease, documenting a left-sided pantonal hearing loss, recurrent vertigo attacks, and persistent tinnitus. Treatment with diuretics and betahistine was applied.

At the last evaluation in 2023 and telephone survey in 2024 (9 years follow-up), symptoms remained unchanged.

Case 3 – Q.L., female

She presented in 2011 at age of 10, with recurrent episodes of vertigo associated with right-sided fullness and tinnitus. Family history was positive for MD (father) and migraine (mother).

Pure-tone audiometry showed a mild right-sided hearing loss (< 40 dB) at 500–1000 Hz.

Vestibular evaluation revealed horizontal spontaneous left-beating nystagmus, rightward rotation on the Unterberger test, and a borderline 20% left labyrinthine preponderance on the rotational test.

At the second visit at age 14, she reported imbalance with nausea. Episodes of right-sided fullness and tinnitus persisted but appeared independent from vestibular symptoms. She reported the onset of several headache attacks during the previous year and received a diagnosis of migraine without aura in a specialized Headache Center. MRI was normal.

Ophthalmologic assessment revealed ocular myasthenia.

At the last clinical evaluation in 2023 and telephone survey in 2024 (13 years follow-up), she reported only migraine headache, with no further vertigo or hearing loss, and only occasional tinnitus.

Case 4 – R.P., male

He presented in 2010 at age of 6, with sudden-onset vertigo but did not report cochlear symptoms. Pure-tone audiometry, however, showed sudden moderate right-sided pantonal hearing loss, more on high frequencies, never previously diagnosed. He never reported headache before.

Vestibular evaluation revealed second-degree left-beating nystagmus, positive HIT on the right side, rightward deviation on the Unterberger test, and 25% left labyrinthine preponderance on the rotational test. CT of the temporal bones and brain MRI were negative.

Vertiginous symptoms resolved quickly, but hearing loss persisted and the child referred persistent right ear fullness and tinnitus.

Over the next 18 months, he suffered four more episodes of worsening hearing and vertigo, less intense and without headache, treated with steroids, with rapid recovery and negative immunological evaluation. Nearly 10 years later, he reported persistent sensorineural right hearing loss and ABR and MRI remained normal.

At the last evaluation in 2023 and telephone survey in 2024 (14 years follow-up), he reported stable right-sided hearing loss, without further episodes of vertigo or headache.

Results

In our sample of 472 paediatric patients with balance disorders, 4 children with Menière-like symptoms and signs were identified, according with the AAO-HNS guidelines from 1995, revised in 2015 (Lopez-escamez et al., 2015).

All four children, 3 females and 1 male, had a mean age of 9.5 years, and presented for recurrent hearing loss, tinnitus, or fullness, in addition to "vertigo"-symptoms, that led to a specialist consultation. Their long-term follow-up ranged from 8 to 14 years.

The cochlear symptoms reported at baseline correlated with pathological findings on pure-tone audiometry in 3 out of 4 cases, and only subsequently a hearing loss was found in the 13-year-old girl with persistent Ménière-like symptoms who initially showed no deficit. During follow-up, pure-tone audiometry normalized in 50% of the children.

Vestibular assessment revealed peripheral-type nystagmus and rotation on the Unterberger–Fukuda test in 75% of cases, contralateral labyrinthine preponderance on the RCT in 50% of cases, and normal vHIT results in all patients.

Brain MRI, child neuropsychiatric evaluation (NPI), and EEG were requested in 50% of the children and were all unremarkable.

Fifty percent of the children—all females—developed migraine headache, and both had a family history of migraine (mother). One of these girls also had a parent with Menière's disease (father). Migraine headache appeared between 1 and 4 years after the first visit.

Based on the long-term follow up of our MD patients, we reformulated our initial diagnosis:

- **Case1 –** *migraine-related symptoms, NON-MD related;*
- **Case 2 –** *left-sided unilateral hearing loss and tinnitus; MD diagnosis was confirmed;*
- **Case 3 –** *migraine-related symptoms, NON-MD related;*
- **Case 4 –** *sequelae of right-sided acute cochleo-vestibular neuritis, NON-MD related.*

Only one diagnosis out of 4 could be confirmed over time, so our previous published percentage of 0.8% of paediatric MD on our sample of 472 children with balance disorders (Balzanelli et al., 2021) is actually much lower. In light of these results, it actually corresponds to 0.2% of the total.

The only MD confirmed diagnosis was in a female of 13 years old. No other cases were younger, in agreement with the results of some previously published case series, in which the prevalence under 10 years was slightly above zero (Brain et al., 1938; Green et al., 1951; Cawthorne et al., 1954; Golding-Wood et al., 1960; Harrison et al., 1962; Thomas et al., 1971; Mizukoshi et al., 1979; Pfaltz et al., 1981; Kitahara et al., 1981; Mizukoshi et al., 2001). This allows researchers to start future investigation on this topic, in order to review the data on the prevalence of MD.

Discussion

The literature shows that Ménière's disease (MD) is rarely observed before the age of 10 (Swain et al., 2022). The mean age of our cases with Menière-like symptoms was 9.5 years, consistent with the literature.

The prevalence of MD in the general population ranges approximately from 17 to 46 cases per 100,000 inhabitants, with variations related to geographic area and the diagnostic criteria used (Sajjadi et al., 2008). Headaches of all types occur as frequently as 70-76% in patients with MD. Migraine specifically shows a comorbid rate of between 22% and 56% in classical MD. Age of onset of episodic vertigo or fluctuating hearing loss is significantly lower in patients with MMD (37,2 years) than in those with MD (49,3 years) (Cha et al., 2007).

In the study by Wang C et al. in 2021, 50% of children with cochlear symptoms and vertigo had vestibular migraine, 31% had BPPV, and 6% had MD (the criteria used for diagnosing MD were less stringent: paroxysmal vertigo lasting more than 20 minutes or fluctuating cochlear symptoms, without other neurological signs).

In our sample of 472 children with balance disorders, nearly 7% (33 children) had also cochlear symptoms (Table 2). Among these, the most frequently diagnosed causes were AUVL (24.2%), and VM (21.2%). Initially, we interpreted 9% of these cases (4/33) as suspected MD, frequently linked with psychogenic vertigo (9%) and otitis media (9%). For this reason, we decided to continue with careful follow-up. Overall, in our initial analysis published in 2021 (Balzanelli et al., 2021), MD-like symptoms were present in 0.8% (4/472) of our children with balance disorders.

We know that the incidence of MD in children could be underestimated, due to their low-capacity to articulate or perceive their own symptoms at a young age. However, the clinician's ability to investigate and explain the symptoms to the child, with the cooperation of the parents, can make the difference.

In our sample, onset was earlier in girls with migraine, consistent with the literature. Fluctuating hearing loss, tinnitus, and sensation of ear pressure may also occur in VM [44]. VM patients may develop hearing loss during a vertigo attack, but the percentage is low (19–25.7%), especially when compared with patients with MD. Audiometric abnormalities are, mild to moderate, unilateral or bilateral sensorineural hearing loss, reversible and slowly progressive. In 25% of cases, coexistence of VM and MD has been demonstrated, making diagnosis a genuine challenge. VM is still poorly understood and underdiagnosed, often misclassified as MD (up to 51.5% error), although in the general population, VM subjects are 5–10 times more frequent (Chen et al., 2023). During the first year after symptom onset, differentiating vestibular migraine from Menière's disease can be difficult, as MD can be monosymptomatic, presenting only vestibular symptoms in its early stages, and vestibular symptoms and headaches may not appear simultaneously. It is only over time that episodes can be classified as Menière-like, migraine-like, or both. Factors that can aid distinction include earlier onset of VM, more common in females, and motion sickness, reported in nearly half of VM patients (hypersensitivity to visual-vestibular conflict). The most sensitive and distinctive feature of VM is a history of recurrent moderate-to-severe headaches, with or without aura. In about 30% of patients, vertigo may occur even without headache (Lopez-Escamez et al., 2015; Chen et al., 2023).

Conversely, VM patients describe vertigo as rotation, fluctuation, oscillation, instability, or light-headedness, worsened by head movements, sometimes positional, sometimes spontaneous. In MD patients, spontaneous vertigo is the most frequently reported type (Chen et al., 2023). In MD, hearing loss progresses and becomes persistent. The Bàràny Society suggests that when the criteria for MD are met, particularly unilateral hearing loss on pure tone audiometry, MD should be diagnosed even if migraine symptoms appear during vestibular attacks. Only patients presenting two different types of attacks—one meeting criteria for vestibular migraine and the other for MD—should be diagnosed with both conditions. A future revision of classification could include a vestibular migraine/MD overlap syndrome (Lopez-Escamez et al., 2015).

Familiar MD in paediatric studies is reported in 33% of cases, correlated with bilateral hearing loss (Wang et al., 2018); however, our only definite MD case was the first in the family and was unilateral. In our series, an essential factor differentiating MD and VM was the association between hearing loss, headache and family history in VM and not in MD, regardless of the type of vertigo attack. The onset in the 13-year-old girl, who proved to have definitive MD in our sample (Case 2), was gradual, initially with few symptoms, but over time, with the progression of endolymphatic hydrops and neuroepithelial damage, the disease gradually produced objective clinical-instrumental alterations, as hearing loss and vertigo attacks, without headache or familial predisposition, which are instead a constant feature in MV (Chen et al., 2023).

After prolonged follow-up (5-14 years), the real true prevalence of definite Ménière's disease in our paediatric population (<18 years) is 0,2% (1/472), not 0.8. This is among the lowest values reported in the literature (0–1,2%) [3-8, 11-13, 17], which can be explained only by our long follow-up—the longest we found in literature.

Many published series lack long-term follow-up or provide unclear guidance in this regard, rarely report headache data or the diagnostic tools used at the time are now obsolete, making the sample inhomogeneous.

Since the literature reports almost 0% of MD cases before the age of 10 (Brain et al., 1938; Green et al., 1951; Cawthorne et al., 1954; Golding-Wood et al., 1960; Harrison et al., 1962; Thomas et al., 1971; Mizukoshi et al., 1979; Pfaltz et al., 1981; Kitahara et al., 1981; Mizukoshi et al., 2001) and also in our case the age of definitive diagnosis of

MD (Case 2) was adolescence, it allows us to assume the hypothesis that the increase in secretion of gonadotropins and sex hormones during the puberal activation of the hypothalamic-pituitary-gonadal axis, may play a decisive role in the complex multifactorial mechanism leading to MD. In fact, it is well known that MD symptoms are exacerbated during the premenstrual period in 5,5% of patients (Andrews et al., 1992). The few related studies, analyze the relationship between female hormonal fluctuations (menstrual cycle, contraception, hormone therapy, and menopause) and the exacerbation of MD symptoms, assessing their impact on auditory and vestibular function (Andrews et al., 1992; price et al., 1994; Grillo et al., 2021; Caruso S et al., 2018; Jian et al., 2019). Currently, there is still little evidence in the literature on this specific topic and further considerations will be merely speculative. Certainly, the diagnosis of MD in children must be made with extreme caution, and only after careful observation of clinical outcomes over the years.

Our study has some limitations. First of all, the sample is very small, as although the total sample of children with balance disorders is numerically well represented, it is a really rare disease in children, but this must induce researchers to join forces by designing a multicenter study in the future, that can provide more precise results. In addition, not all children performed caloric tests and VEMPs, making the differential diagnosis less precise.

Conclusions

A minimum follow-up of 5 to 14 years on our sample of 472 patients collected over 10 years from 2010 to 2019 and the retrospective critical analysis of our epidemiological data regarding paediatric patients with MD, allow us the following considerations:

1. Menière-like symptoms and signs in children with balance disorders are extremely rare at first diagnosis.
2. Thanks to careful and long-term follow-up, we can now confirm our initial diagnosis of MD in only 0.2% of cases, instead of 0.8%, as previously published (Balzanelli et al., 2021). In our sample, 75% of patients initially diagnosed as MD, later developed other pathologies other than MD.
3. No confirmed definitive diagnosis of MD under 13 years of age over the years.
4. 50% of cases of initial diagnosis of MD develop migraine dizziness at a later age.
5. A stereotyped clinical picture of recurrent unilateral hearing loss and headache in children could be a possible indicator of the definitive diagnosis of MD at subsequent long follow-up, regardless of vestibular findings.
6. Long-term follow up of MD symptoms in the paediatric age is mandatory.

These considerations suggest new areas for future research about epidemiology and aetiopathogenesis of paediatric MD (female sex hormones, cognitive, familiar or neurodevelopmental correlation, etc).

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of ASST Spedali Civili Brescia (protocol code 83787; approval date: 2019, 20 November).

Informed Consent Statement: Informed consent was obtained from the parents of all the subjects involved in the study. **Data Availability Statement:** The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy.

Conflicts of Interest: The authors declare no conflicts of interest.

TABLES

STUDY	YEAR	Percentage of MD children by age
Brain WR et al. [3]	1938	0-9 years: 0% 10-19 years: 2,4%
Green, RE et al. [4]	1951	0-9 years: 0% 10-19 years: 3,4%
Cawthorne Tet al. [5]	1954	0-9 years: 0% 10-19 years: 1,4%
Golding-Wood PHet al. [6]	1960	0-9 years: 0% 10-19 years: 1,9%
Harrison, MS et al. [7]	1962	0-9 years: 1,2% 10-19 years: 1,4%
Thomas Ket al. [8]	1971	0-9 years: 1% 10-19 years: 1%
Stahle Jet al. [9]	1978	0,4%
Meyerhoff WL et al. [10]	1978	3%
Mizukoshi K et al. [11]	1979	0-9 years: 0,19% 10-19 years: 5%
Pfaltz CRet al. [12]	1981	0-9 years: 0% 10-19 years: 0%
Kitahara M et al. [13]	1981	0-9 years: 0% 10-19 years: 5%
Filipo R et al. [14]	1985	7%
Yanagida M et al. [15]	1986	0%
Hausler R et al. [16]	1987	1,1%
Mizukoshi K et al. [17]	2001	0-9 years: 0% 10-19 years: 2,7%
Akagi H et al. [18]	2001	0,07%
Choung YH et al. [19]	2006	2,6%
Wang C et al. [20]	2018	2,3%
Wienere-Vacher S et al. [21]	2018	1,1%
Brodsky JR et al. [22]	2019	0%
Wang A et al. [23]	2020	0,1%
Balzanelli C et al. [1]	2021	0,8 %

Table 1 - Percentage of children among patients with Menière's disease: comparison of studies over years (Balzanelli et al., 2021; Brain et al., 1938; Green et al., 1951; Cawthorne et al., 1954; Golding-Wood et al., 1960; Harrison et al., 1962; Thomas et al., 1971; Stahle et al., 1978; Meyerhoff et al., 1978; Mizukoshi et al., 1979; Pfaltz et al., 1981; Kitahara et al., 1981; Filipo et al., 1985; Yanagida et al., 1986; Hausler et al., 1987; Mizukoshi et al., 2001; Akagi et al., 2001; Choung et al., 2006; Wang et al., 2018; Wiener-Vacher et al., 2018; Brodsky et al., 2020; Wang et al., 2021).

Disease	N. of children with vertigo and cochlear symptoms at presentation	Incidence
AUVL	8	24,2%
MV	7	21,2%
MD (suspected)	3	9%
Psychogenic vertigo	3	9%
Effusive otitis	3	9%
BPPV	2	6%
Unknown	2	6%
Ocular disorders	1	3%
Arterious hypotension	1	3%
Epilepsy	1	3%
Postural disorders	1	3%
Trauma sequelae	1	3%

Table 2 – Prevalence of cochlear symptoms at presentation in children with balance disorders (Balzanelli C et al., 2021).

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