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Correlation between otitis media with effusion and cranial deformation in children

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Abstract. – OBJECTIVE: Otitis media with effusion (OME), defined as the presence of fluid in the ear without signs of an acute infection, usually occurs after acute otitis media and could result in reduced sound transmission with hearing loss. Several risk factors have been suggested to be associated with OME, as well as the relationships between morphology anomalies of cranial bones and ear infections. The aim of this study is to investigate the correlation between OME and cranial deformation in a pediatric population.

PATIENTS AND METHODS: Eighteen children (13 males and 5 females) with a diagnosis of unilateral OME based on otolaryngologic examination, conductive hearing loss and an asymmetric tympanogram type were enrolled in the study. Patients underwent osteopathic and physical examinations to evaluate the presence of cranial deformations.

RESULTS: Our study showed a high percentage of skull asymmetry (94%) in the study sample; children were mainly dolichocephalic and with atypical swallowing (72%). Particularly, we observed an occipital flattening, mainly ipsilateral to the ear affected by OME.

CONCLUSIONS: The results of the present study indicated that a high percentage of children with OME present a skull asymmetry with concomitant dolichocephaly, known to be associated with high arched palate which is also related to a higher incidence of OME.

Key Words
Otitis media with effusion, Atypical swallowing, atypical swallowing, Plagiocephaly, Dolichocephaly, Skull asymmetry, Osteopathy.

List of Abbreviations

OME: otitis media with effusion; OMA: acute otitis media; ET: eustachian tube; SIDS: Sudden Infant Death Syndrome, CVAI: Cranial Vault Asymmetry Index; SD: Standard Deviation; ROM: Range of Motion.

Introduction

Otitis media with effusion (OME), defined as the presence of fluid in the middle ear without signs of an acute infection, usually occurs after acute otitis media (OMA) and might result in conductive hearing loss. About 90% of children suffer from OME in preschool but its incidence is difficult to determine since the disease is asymptomatic and self-limiting in the majority of cases[1-5]. Most OME cases heal spontaneously within 3 months, but some children may have several episodes exceeding one year in duration. Several studies demonstrated that OME episodes, persisting for months or years before the primary school, can be responsible for early childhood hearing impairment that depending on severity, can lead to speech development disability, mental developmental disorders, and alteration in language learning as well as in the emotional and learning spheres[2,6,7]. These effects are usually detectable in the short-term; however, in children who have recurrent episodes of OME, the effects on behavior and language may be detectable up to 10 years of age. In addition, there are data showing the OME is often associated with hyperacusis and behavioral disorders such as hyperactivity, poor attention, learning difficulties, sleep disturbances, and reduced mobility[8-13]. It is already known that anatomical (short, flaccid and horizontal) and physiological (dynamic opening and mucociliary function) characteristics of the Eustachian tube (ET) contribute to its function; various degrees of alteration of ET function may negatively impact the ear ventilation in the child and increased probability of developing an OME[14-16]. In this context many studies have shown favorable clinical outcomes in children treated with manipulative

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medicine in addition to standard care[17,18]. During the birth process, indeed, the force of labor can affect the position and the motion of the cranial bones inducing cranial dysfunction that, if untreated, are thought to predispose the child to middle ear infections. Furthermore, several studies have suggested the increase of OMA in severe plagiocephaly, a skull deformity which incidence is significantly increased since 1992 as a result of the "Back to Sleep" campaign to prevent Sudden Infant Death Syndrome (SIDS)[19]. The developing skull is deformed by the pressure exerted by the weight of the child's head, which is always positioned in the supine position, leading to real deformations of the occipital part of the skull and to a condition of plagiocephaly, classifiable according to gravity according to Cranial Vault Asymmetry Index (CVAI)[20]. The relationship between skull deformity and OME requires further investigation to be fully understood. The aim of this study is to investigate the relationship between skull deformation and OME in children.

Patients and Methods

Patients

The study was conducted in a tertiary referral University Hospital. A total of 445 consecutive pediatric patients with the main complaint of subjective hearing loss were screened for eligibility between June 2015 and February 2017. All patients with the following conditions were excluded: congenital anomalies (cleft palate or Down syndrome), gastro esophageal reflux, delayed speech, dyslexia, autism, behavioral or cognitive disorders, cystic fibrosis, allergy. All patients underwent a full otolaryngologic clinical examination, audiometric test (play audiometry or tonal audiometry, and tympanometry. At the end of the evaluation, 18 children with unilateral OME and an asymmetric tympanogram type (A type / B type; A type / C type; B type / C type) were included in the study. Written informed consent was obtained from the parents. Patients included in the study underwent osteopathic skull evaluation and orthopedic examination to exclude other concomitant diseases. Clinical data and information concerning the posture of the infants were collected using a standardized questionnaire by a research assistant (Table I).

The osteopathic examination aimed to establish head posture, active cervical rotation, passive cervical joint functioning, and muscle impairment. The osteopathic practitioners evaluated and classified all the cranial bones following the CVAI classification and the Argenta's classification[21].

The study protocol was approved by the Committee of Medical Ethics of the Sapienza University of Rome and followed the Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects. The CVAI was calculated by dividing the skull circumference into

Table I. Perinatal and postnatal questionnaire.

Name:	Date of Birth:
Born at week:	Type of delivery: (Vaginal, Cesarean)
Forceps or vacuum delivery:	Apgar Index:
Weight:	Neonatal Intensive care: (Yes or No)
Breast of Formula feeding:	Preferred side of baby:
Cranial malformation at birth:	frequent supine position: (Yes or No)
Soother: (Yes or No)	Walker: (Yes or No)
Frequent activity of the baby (Yes or No) – Lie on the stomach – Sit up – Stand – Crawl – Roll – Stay on the knees – Walk	Frequent problems of the baby (Yes or No) – Colic – Reflux – Colitis – Constipation – Asthma – Allergy – Sleep disorders – Growth delay
Additional Information – Trauma: – Surgical intervention: – Infections: – Inflammations: – Other therapies:	

quadrants, at the level above the ridge of the nose and with a line connecting the ears and a perpendicular line drawn with the center of the nose as reference. From the intersection of these two lines, 40° is measured to the left and right giving two diagonals (A and B). The length of the diagonals is measured and the difference in length of the diagonals divided by the smaller diagonal provides the asymmetry index expressed as a percentage. A value greater than 3.5% regardless of head circumference is defined as significant asymmetry.

Data are reported as means ± Standard Deviation (SD). Fisher's exact test was used to analyze the symmetry differences between the two sides, a $p<0.05$ was considered significant.

Results

Eighteen patients were included in the study (13 males and 5 females), mean age 6.3±2. All patients presented a conductive hearing loss with an asymmetric tympanometry.

Most of the children examined in our sample were males (72%) and showed a cranial morphology of dolichocephalous type (94%), with a higher incidence of cranial symmetry changes at mild level (5.2%) detected by CVAI. The left side was affected in 13 children (72%); the right side in 5 children (28%) (Table II). Atypical swallowing was found in 72% of the children.

A correlation between ear infection and flattening of occipitomastoidae ipsilateral region was observed although not attributable to a stage of Argenta's classification. Finally, a limitation in cervical range of motion, mainly cervical active rotation, was found in 13 children (72%). The direction of detected Range of Motion (ROM) limitations was always coherent with the biomechanical role of sternocleidomastoid muscle, being detected in all cases contralaterally to the side of head positional preference for the rotations, and ipsilateral to the side of head positional preference for lateral flexion. Table III shows the type of cranial dysfunction reported in the osteopathic examination.

Table II. Demographics and clinical characteristics of participants with chronic otitis.

Clinical features		p
Patients	18	
Age (years)	6.3 +/- SD 2	
Sex (female/male)	5/13: 72% male	0.05
Affected side (right/left)	5/13: left 72%	0.05
Ear shifted (right/left)	5/13: left 72%	0.05*
Cranial asymmetry	94%	0.02
CVAI	5.2%	
Cephalic index	72.5	

CVAI: cranial vault asymmetry index.

Discussion

The results of the present study demonstrate that a high percentage of children with OME present a skull asymmetry with concomitant dolichocephaly, known to be associated with high arched palate which is also related to a higher incidence of OME. Furthermore, some studies reported the presence of atypical swallowing in OME patients, and other studies suggested its association to dolichocephaly, although with much controversy[22-27]. Our results, instead, showed the simultaneous presence of the three elements that are probably connected and perhaps mutually reinforcing. Skull evaluation and the presence of atypical swallowing should always be taken in account in this subset of patients during otolaryngologic clinical examination. Indeed, the study of the deglutitory system is a valid tool since this apparatus is strictly correlated with the physiological function of the ET. The tensor muscle of the palate originates from the sphenoid and is inserted in the soft palate. Innervated by the fifth cranial nerve, its function is to contract the soft palate. A dysfunction in the act of contraction can give rise to pathologies such as rhinogenic infantile deafness, as it can alter the dynamics of the ET. If the masticatory muscles are hypertonic, also the tensor of the palatal veil might be hypertrophic, leading to a long-lasting blockage of the middle ear drainage. A spasm involving the internal pterygoid muscle would not allow the palatal

Table III. Type of osteopathic cranial dysfunction.

Cranial dysfunction	Prevalence	p
Left temporoparietal	78%	0.05
Left occipital mastoid	72%	0.05
Right lateral flexion	83%	0.05
First rib and /or vertebral artery	94%	0.02
Cervical ROM limitation	72%	0.05*

ROM: Range of Motion.

veil tensor to open the ET. Moreover, a posterior dislocation of the condyle or an inflammation of the posterior part of the meniscus can interfere with the drainage of the middle ear by blocking the tympanic orifice of the tube. Skull base growth, depending on the basicranium synchondroses along with the occipital, sphenoid and temporal bones, is responsible of much of the cranial lengthening. Di Francesco and colleagues investigated the influence of craniofacial morphology on OMA and retrospectively documented that children with OMA show shorter anterior cranial base length and upper facial height than children without OMA, concluding that deviations in craniofacial growth and development cause anomalies in the position of the ET that can increase the tendency to contract OMA[14,25]. In addition to this, in severe plagiocephaly, the skull deformity may cause the ear to move forward, determining abnormalities of the ET that may cause problems with fluid drainage from the middle ear, promoting infections and otitis media as detected by tympanogram measurements[28,29].

Conclusions

The results of the present study show that – in our sample – a high percentage of children with OME also present a skull asymmetry. Despite the relatively low number of patients included in this study, the high percentage of cephalic asymmetry in these children suggests to include cranial morphology among the factors considered in the evaluation of patients affected by OME. The link between head shape and otolaryngologic diseases could help better understand the clinical efficacy of the osteopathic treatments reported in anecdotal way by OME patients, proposing to study the effectiveness of skull manipulation in OME management. Further investigations on larger samples are needed to better comprehend the significance of these findings and the relationship between plagiocephaly and middle ear diseases.

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Conflict of Interests

The authors declare that they have no conflict of interest.

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