The Journal of Laryngology & Otology (2007), ***121***, *943–946.*

doi:10.1017/S0022215107007347
Printed in the United Kingdom
First published online 10 April 2007

Main Article

Role of otoacoustic emission in children with middle-ear effusion and grommets

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Abstract

Objective: To evaluate the role of otoacoustic emission in children with middle-ear effusion and grommets.

Materials and methods: A prospective study was carried out on a total of 90 ears. All children listed for grommet insertion had a pre-operative and post-operative (three to six months after grommet insertion) pure tone audiometry, tympanometry and otoacoustic emission recorded. A comparison was made between pure tone audiometry and otoacoustic emission both pre-operatively and post-operatively.

Results: Pre-operatively, 63 ears had an abnormal pure tone audiometry of which 59 had absent otoacoustic emission. Therefore the sensitivity of otoacoustic emission in detecting a conductive loss was $59/63 = 94$ per cent (95 per cent confidence interval 85 to 98 per cent). All 27 ears with normal hearing pre-operatively had normal otoacoustic emission. The specificity of otoacoustic emission was $27/27 = 100$ per cent, (95 per cent confidence interval, 88 to 100 per cent). The positive predictive value was $59/59 = 100$ per cent (95 per cent confidence interval, 94 to 100 per cent). After three to six months all post-operative patients with grommets had a normal pure tone audiometry and otoacoustic emission. So both pure tone audiometry and otoacoustic emission were strongly related both in patients with middle-ear effusion and in patients with grommets.

Conclusion: As the demonstration of hearing in young and difficult-to-test children can be problematic and time-consuming, we suggest that otoacoustic emission can be used as an alternative to pure tone audiometry in patients with middle-ear effusion and grommets.

Key words: Otoacoustic Emissions; Otitis Media with Effusion; Grommet Insertion; Audiometry

Introduction

For screening of middle-ear effusion and follow up of grommet insertion, pure tone audiometry (PTA) and tympanometry are widely accepted. Paediatric hearing assessment is an important means of confirming glue ears and normal hearing following grommet insertion. However, in young and difficult-to-test children, this can be labour-intensive and time-consuming. Otoacoustic emission using transient evoked otoacoustic emission is relatively quick and simple to perform. Transient evoked otoacoustic emission was first described by Kemp[1] in 1978 and is in widespread clinical use particularly in children. The emissions are produced by the cochlear outer hair cells in response to a stimulus sound and are transmitted by middle-ear structures to a microphone in a probe in the ear canal.

Evoked emissions have several advantages including objectivity, non-invasiveness and specificity for testing the biomechanical activity of outer hair cells, which are the most fragile class of receptor cells of the organ of Corti.[2] Otoacoustic emissions are currently undergoing comprehensive evaluation in a number of clinical settings in order to determine their adequacy as objective tests of hearing.[3–5]

Many of the initial attempts to examine the practical utility of emitted responses have revealed that the non-invasive properties of emissions involving the placement of an acoustic probe in the outer ear canal make these measurements promising for application in difficult-to-test subjects such as infants and young children.[6–9] The other major advantages of emissions that make them attractive to use are their objectivity and the fact that they can be used in subjects where compliance is typically difficult. Therefore it is clear that young patient populations would benefit from emission testing and the feasibility of such an application in a group of subjects with middle-ear effusion has not yet been adequately studied.

The aim of our study was to determine the role of otoacoustic emission in children with middle-ear effusion and grommets. Transient evoked otoacoustic emission has been satisfactorily recorded from

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Presented at the British Association of Paediatric Otolaryngology Meeting, 9 September 2005, Edinburgh, UK.
Accepted for publication: 23 January 2007.

ears with grommets in situ,[10] but a small study of 32 children showed no increase in otoacoustic emissions immediately following grommet insertion for otitis media with effusion.[11] The presence of blood at the myringotomy site, or of residual middle-ear fluid was felt to have reduced the likelihood of obtaining a response. General anaesthesia has also been shown to reduce the amplitude of transient evoked otoacoustic emission.[12] This is mainly due to the diffusion of nitric oxide into the middle ear, causing an increase in pressure, which would be released once a myringotomy was made. In our study, PTA, tympanometry and otoacoustic emission were recorded at least three months after grommet insertion.

Materials and methods

This was a prospective study of patients between two and 15 years undergoing grommet insertion for middle-ear effusion. The mean age was 7.5 years and the median age was four years. In total, 42 out of the 90 ears tested (46 per cent) were from patients less than four years, 28 ears (31 per cent) were from children between four and seven years and the remaining 20 ears (23 per cent) from patients between seven and 15 years. Therefore, about half of the patients were less than four years and three-quarters were less than seven years. Patients diagnosed with middle-ear effusion and listed for grommet insertion were included in the study. Those children undergoing adenoidectomy or tonsillectomy at the same time as grommet insertion were excluded from the study.

Pre-operatively, all patients had a pure tone audiometry, tympanometry and otoacoustic emission recorded. Pure tone audiometry was carried out over all frequencies. Both air and bone conduction were done separately in each ear using insert earphones. Conductive loss was defined as a hearing threshold of more than 20 dBHL (hearing level) at two or more frequencies with a minimum air bone gap of 10 dBHL at those frequencies. An experienced senior audiologist performed otoacoustic emissions using the Otodynamics ILO-88 system (Otodynamics Ltd, Hatfield, Herts, UK) in a non-linear mode with the Quick screen option. The stimulus amplitude was automatically optimised. The tests took place in a soundproofed room in the audiology department. In all cases informed consent was obtained from the child's parents. Otoacoustic emissions were recorded as present or absent using a modification of the classification used by Owens *et al.*[10] To be classified as present, the recording had to show a whole wave reproducibility of 50 per cent or more and a signal-to-noise ratio of greater than or equal to +3 dB in the middle three frequency bands. Any recording that did not meet all of the specified criteria was categorised as absent. No attempt was made to classify emissions as reduced or partial responses as done in some previous studies[13,14] as this does not provide clinically useful information for the purpose of this study. In all cases, Sheppard's grommets were inserted. Patients were seen three to six months after grommet insertion and, again, PTA, tympanometry and otoacoustic emission were recorded. All ears were examined prior to the tests and only ears with grommets in situ and patent grommets were included in the study.

Results

Out of the total 90 ears studied, pre-operatively, 63 ears showed evidence of conductive loss on PTA and the remaining 27 ears had normal hearing. Of the 63 ears which had conductive loss, 25 had a type A tympanogram, 17 had a type C tympanogram and the remaining 21 ears had a type B tympanogram. In total, 59 of the 63 ears with conductive loss on PTA pre-operatively had an absent otoacoustic emission. The four ears that had a conductive hearing loss on PTA and a normal otoacoustic emission had a type A tympanogram. Therefore the sensitivity of otoacoustic emission in detecting a conductive loss was $59/63 = 94$ per cent, (95 per cent confidence interval [CI], 85 to 98 per cent). Of the 27 ears which had normal hearing, 21 had a normal tympanogram (type A) all of which had a normal otoacoustic emission, three had a negative middle-ear pressure (type C) tympanogram all of which had a normal otoacoustic emission and the remaining three had a flat tympanogram (type B) all of which had a normal otoacoustic emission.

All 27 ears with normal hearing on PTA pre-operatively had a normal otoacoustic emission. The specificity of otoacoustic emission was $27/27 = 100$ per cent (95 per cent CI, 88 to 100 per cent). The positive predictive value was $59/59 = 100$ per cent (95 per cent CI, 94 to 100 per cent). So there was a strong relationship between PTA and otoacoustic emission pre-operatively. The three ears that had a type B tympanogram with a normal PTA and otoacoustic emission may be due to very little fluid in the middle ear, which did not affect the transmission of sound and therefore gave rise to a normal otoacoustic emission and PTA.

Post-operatively, three to six months after grommet insertions, all patients who had a normal PTA had otoacoustic emission present. Grommets did not seem to have an effect on the otoacoustic emission. Therefore, there was a strong relationship between PTA and otoacoustic emission even post-operatively.

Discussion

Otoacoustic emission has been used widely in newborn screening of hearing and is used to detect sensorineural hearing loss due to failure of outer hair cells.

It is clear from past findings in adults that otoacoustic emission provides useful information about hearing function at the outer hair cell stage of auditory processing.[15] However, in infants and children who represent young patient populations that are prone to middle-ear disease in the form of middle-ear effusion and eustachian tube dysfunction, such pathology compromises the validity of the tests of evoked emissions mainly aimed at evaluating the

https://doi.org/10.1017/S0022215107007347 Published online by Cambridge University Press

status of the biomechanical function of the outer hair cells. Therefore, any mild degree of hearing loss associated with otitis media has an impact on the expression of otoacoustic emission. Although PTA has the advantage of frequency specificity, it can be misleading and time-consuming in the detection of middle-ear effusion and hence otoacoustic emission scores a real advantage over PTA. However, if there is a suspicion of low frequency cochlear hearing loss and more frequency-specific hearing levels are required, then PTA can be performed.

Tympanometry primarily examines the stiffness of the eardrum using low frequency tones. Otoacoustic emission, on the other hand, requires normal middle-ear function from 1 kHz. Otoacoustic emission therefore provides evidence of normal middle-ear function, strongly biased towards the transmission properties of the middle ear at speech frequencies rather than its sound reflection properties. This additional information is, of course, available only where the cochlea is known to be normal. The quality and integrity of surgical reconstruction of the middle ear could be assessed using otoacoustic emission.

- **Previous studies have shown that middle-ear effusion reduces the number of measurable responses and their amplitudes in distortion produce otoacoustic emissions and the evaluation of otoacoustic emission immediately after or a few hours after grommet insertion does not give an accurate measurement of otoacoustic emission**
- **This study shows that otoacoustic emission is an effective means of confirming middle-ear effusions with a close relationship to pure tone audiometry. Otoacoustic emissions are also an effective means of confirming normal hearing when performed three months after grommet insertion**
- **As the demonstration of hearing in young children can be problematic and time-consuming using PTA, we suggest that otoacoustic emission could be used as an alternative to audiometry in patients with middle-ear effusion and grommets**

Middle-ear effusion would be expected to affect otoacoustic emission both by reducing the transmission of emissions from the cochlea through the middle ear and by attenuating the stimulus reaching the cochlea. The study by Topolska *et al.*[16] has shown that effusion in the middle ear reduces the number of measurable responses and their amplitudes in the distortion produce otoacoustic emissions. Our study showed that PTA and transient evoked otoacoustic emission were significantly related in patients with middle-ear effusion. Previous studies for evaluation of otoacoustic emission after grommet insertion were done immediately after grommet insertion under general anaesthesia. Tilanus *et al.*[11] recorded normal emissions in 20 per cent of the ears while Richardson *et al.*[14] found normal results in only 10 per cent and Erwig *et al.*[17] found that otoacoustic emissions were observable in only 12 per cent of children with flat tympanograms and that they were always absent when the conductive loss exceeded 20 dB. In a study done by Cullington *et al.*,[18] otoacoustic emissions were measured a few hours after grommet insertion before the patient was discharged. This study obtained a normal otoacoustic emission in 43 per cent of ears suggesting that the time elapsed between surgery and testing had significantly increased the pass rate. This study also showed that the majority of the children had normal hearing at their review appointment several weeks after grommet insertion suggesting that there was some mechanism that reduces or abolishes otoacoustic emission during grommet surgery.

All the previous authors[15,16,18] have postulated that the effects of temporary threshold shift following suctioning or mechanical trauma to the middle ears may explain the low otoacoustic emission pass rate. In our study, otoacoustic emission was done three to six months after the insertion of grommets and therefore showed a strong relationship between conductive loss and reduced otoacoustic emission. Our study showed that all patients with normal PTA following grommet insertion had a normal response on otoacoustic emission. Therefore, we conclude that otoacoustic emission is an effective means of confirming middle-ear effusion pre-operatively. It is also an effective means of confirming normal hearing after grommet insertion when performed at least three months after insertion. We have shown that both PTA and otoacoustic emission are strongly related both in patients with middle-ear effusion and patients with grommets. As the demonstration of hearing in young and difficult-to-test children can be problematic and time-consuming using PTA, especially in younger children, we suggest that otoacoustic emission could be used as an alternative to PTA in patients with middle-ear effusion and grommets.

Acknowledgements

We acknowledge Julie Morris, Head of Medical Statistics, South Manchester NHS Trust for helping us with the statistics for this study. We also acknowledge Tracy Glower, Chief Audiologist, Stepping Hill Hospital for helping with the recording of the hearing tests.

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Mr Y Saleem takes responsibility for the integrity of the content of the paper.
Competing interests: None declared