

How lockdown has unlocked new potential for remote glue ear management

Surina Fordington describes how *Hear Glue Ear* was used in one local authority's glue ear plan

Glue ear, also known as otitis media with effusion (OME), is the commonest cause of hearing loss worldwide and affects one in five preschool children at any time.¹ In glue ear, there is accumulation of serous fluid in the middle ear, which impairs the transmission of sound waves to the inner ear and may result in a significant hearing loss. Glue ear is most common in four-year-olds, which coincides with a critical time window for speech and language development and starting school in the UK. In most cases, glue ear resolves spontaneously in a matter of months, as the serous middle ear fluid reabsorbs. However, in some cases it may persist and result in long-term hearing impairment. The subsequent loss of audible cues at a critical period of development has been shown to result in disorders of speech and language and, in more extreme cases, is associated with impairments in long-term educational and social outcomes.² These long-term consequences are especially problematic for children with conditions predisposing them to developmental delay, such as Down syndrome, who are additionally at increased risk of developing glue ear. Studies have shown that intervening early in children with chronic glue ear can have lasting impacts on their long-term developmental trajectory.

The current UK standard for glue ear management includes initial assessment by a paediatric audiologist,

usually following referral from their GP, health visitor or school, followed by a 'watchful waiting' period of three months to give time for spontaneous resolution.³ Following this, there is repeat audiology assessment with subsequent referral to ear, nose and throat (ENT) for consideration of grommet insertion. Whilst it reduces the risk of unnecessary procedures, this pathway can mean that children with chronic glue ear may spend up to two years with their hearing reduced (National Institute for Health and Care Excellence (NICE) guidance CG60) before receiving an intervention, which can significantly delay their speech and language development. During the Covid-19 pandemic, reduced face-to-face consultations and a temporary pause on grommet operations have exacerbated these delays. In addition, the challenges of home learning during lockdown have brought to the fore the need to develop new methods to support children with hearing loss remotely. Whilst the pandemic has lent these issues new urgency, this is not a recent revelation for Cambridge community paediatrician, Dr Tamsin Brown.

After her own daughter suffered from prolonged hearing loss due to glue ear, Tamsin began to explore the role of hearing aids in supporting the children she looks after as a paediatrician specialising in audiology. In particular, bone-conducting headsets transmit sounds as vibration directly via the bones of the skull to the inner ear, thereby



Figure 1: Children using the *Hear Glue Ear* headset and app

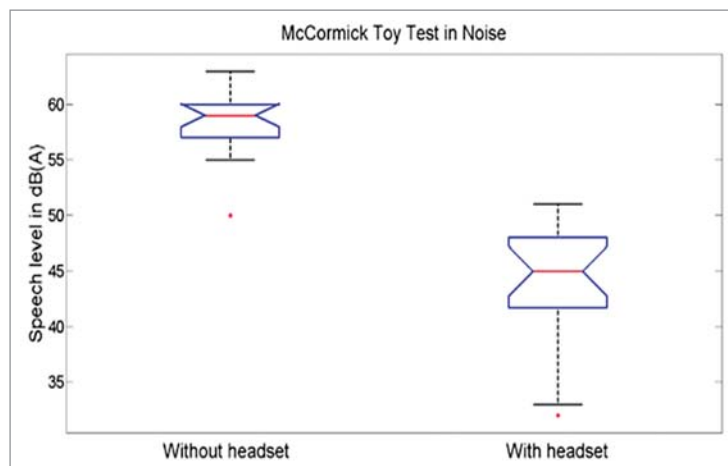
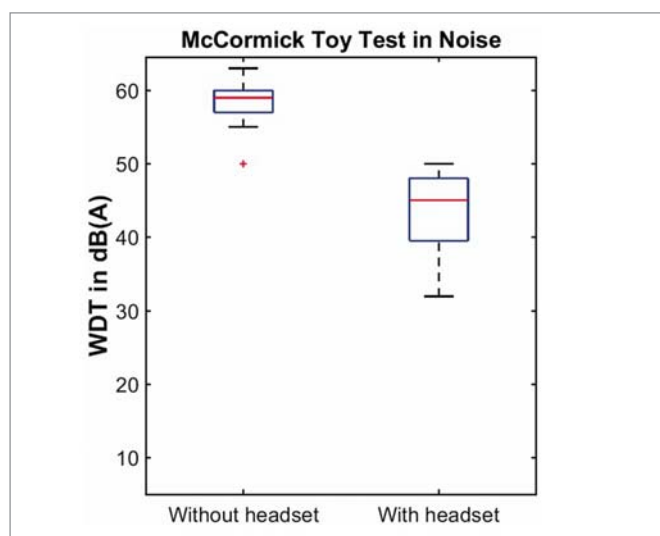


Figure 2. McCormick Toy test showing speech discrimination with and without the bone conduction headset (lower dB indicates increased sensitivity of hearing)



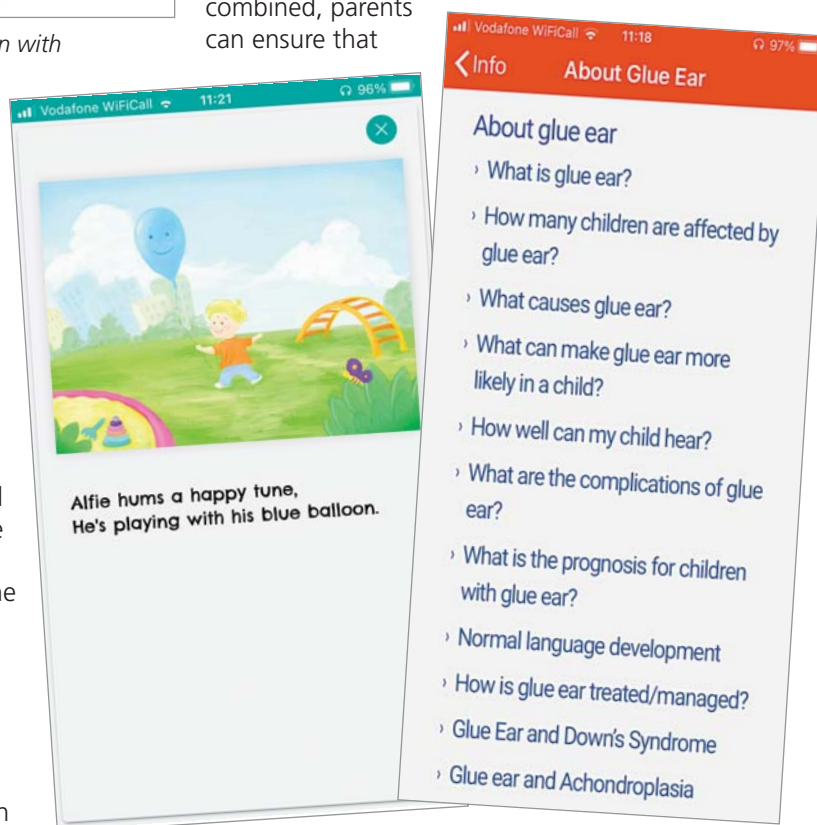
McCormick Toy test showing word discrimination with and without the bone conduction headset

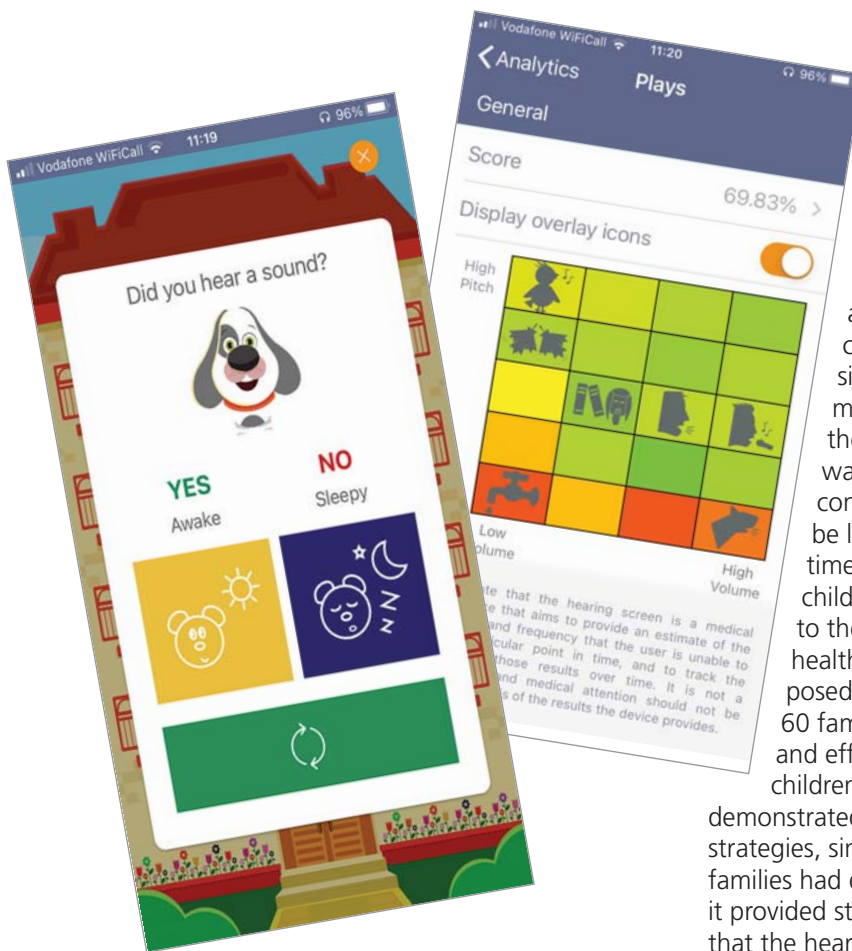
bypassing the middle ear fluid. They do not require any additional programming, since sounds are transferred directly to the healthy inner ear. Children can be exposed to specific audio-acoustic stimuli, without amplifying background noise, in contrast to behind-the-ear hearing aids that are also available.⁴ Soft band bone conduction headsets currently cost the National Health Service (NHS) thousands of pounds apiece, despite their constituent parts being relatively affordable. In her quest to find a more affordable alternative, which included starting a mini home-production line at one point, she found a solution in an unexpected field: the athletics industry. Bone conduction headsets are widely used by professional cyclists, since they enable athletes to communicate with their coach whilst keeping their ears open to traffic sounds. Surprisingly, these commercially available bone conduction headsets cost a fraction of equivalents currently available on

the NHS. With the support of audiologist, Josephine Marriage, speech and language therapist, Alex Best and ENT surgeon, Roger Gray, a study assessed whether these headsets could be applied to medical settings, in particular supporting children with temporary hearing loss.⁵ They found that the headsets (Figure 1) significantly improved hearing ability in the McCormick Toy Test (an average increase of 16 dB, which is higher than the average improvement following grommet insertion found by a Cochrane systematic review)⁶ and produced a notable improvement in children's concentration levels (see figure 2). In contrast to many hearing devices available, children were happy to wear these 'sporty' devices at school and at home. The headsets

can be paired to a microphone, which can be held by a parent or teacher (see figure 3) or may be connected via Bluetooth to a phone or tablet. In light of these overwhelmingly positive results, Tamsin considered whether the headset could be taken a step further, by pairing it via Bluetooth to a mobile application specifically designed to support the speech and language development of children with glue ear.

With the technical expertise of Cambridge Digital Health, and generous funding from the Cambridge Hearing Trust, Hear Glue Ear was created, a mobile application which is the first of its kind to specifically target speech and language development for children with hearing loss. Designed with input from audiologists, speech and language therapists and Qualified Teachers of the Deaf, Hear Glue Ear contains a range of interactive listening games, audiobooks and phonic-based activities to specifically target the developmental areas affected by glue ear (see figure 4). So, with the headset and app combined, parents can ensure that





to assess how their child's hearing had changed between appointments. Glue ear often presents with behavioural problems in children, as they struggle to hear instructions, and may become frustrated at being unable to communicate. In response to this feedback, a game-based hearing test was added to the app, which uses pure tone and speech sounds to estimate trends in children's hearing levels. This addition had a significant impact on parents' ability and motivation to take an active role in supporting their child's hearing during the 'watchful waiting' period. During its design, there were concerns about whether the app's uptake would be limited by parental concerns about screen time and carers' time availability to support their child using it, which have previously been barriers to the development of high-quality paediatric health apps.⁸ To explore whether these concerns posed a significant barrier, an evaluative study with 60 families was carried out, assessing the uptake and effectiveness of the app, and its acceptability to children, carers and clinicians.⁹ The results

demonstrated families' eagerness for home-based support strategies, since after one week of follow-up, 87% of families had downloaded the app at home and 85.7% felt it provided strategies to help their child. 85% also found that the hearing screen made it easier to report their child's hearing levels to their clinician. Of the 18 clinicians who took part in the study, 77.8% supported their patients using the app regularly. These results highlighted the enthusiasm of families for additional support and a potential role for mobile health in facilitating this. NICE further supported the use of the Hear Glue Ear app in the glue ear pathway by promoting it through a shared learning example.¹⁰ The app has since gone on to be awarded Children's App of the Year in the 2019 UK App

their child is not only able to hear, but they are exposed to the correct array of sounds to optimise their speech and language development during such a critical period. The app also contains a secure portal to enable speech and language therapists to provide remote material, since studies have found that children often engage with speech therapy better through technology.⁷ There is also an information section, providing information on glue ear and its management from trusted sources. During the Covid-19 pandemic, Qualified Teachers of the Deaf, Sibel Djemal, Angela Howgate and Amarinda Benson, created a 'glue ear care plan' to allow parents to share information with teachers via the app. They started to provide sensory support to some of the local children who had taken the equipment into school and will be reviewing their findings at the end of the year.

Patient and Public Involvement (PPI) data from the headset study highlighted feelings of frustration and disempowerment amongst parents from being unable



Figure 3. The bone conduction headset can be paired to a microphone, which may be held by a parent or teacher

Awards and the BAPA App award in 2021.

The management of glue ear in children has been significantly impacted by the Covid-19 pandemic. With grommet surgeries named amongst the lowest priority surgeries and local community audiology services closed to referrals from April to September 2020, many children have experienced significant delays to treatment, and prolonged periods with reduced hearing. As discussed above, delays in management of childhood hearing loss increase the risk of long-term developmental delay, so the national lockdown has accelerated the need to find new ways of supporting children remotely. The Hear Glue Ear headset and app have been reliably shown to provide a remote means of not only monitoring, but also supporting children's hearing levels. In order to ascertain whether they could provide a practical tool for families during the pandemic, Tamsin and ENT colleagues, Ms Bewick and Ms Fitzgerald O'Connor, posted Raspberry Pi bone conduction headsets and instructions of how to download the Hear Glue Ear app to 26 families whose children had a glue ear diagnosis.¹¹ Despite being given instructions remotely, families were able to learn to use the headset and app easily and the children who took part were happy to use them at home and at school, when they reopened. Over 90% of OMQ-14 responses were positive, and parents consistently reported that their child's behaviour had improved at home and that they felt their speech was clearer. One child reported that they could finally hear their best friend again! It was encouraging to see families embrace the app and headset into home and school routines and to observe significant improvements in speech outcomes in remote consultations for children who had used the app and headset. The results of this study introduced the possibility of remotely monitoring and managing glue ear while face-to-face consultations and surgical interventions are reduced. However, pressure on primary and secondary care services and avoidance of unnecessary surgery in self-resolving cases mean that periods of prolonged hearing loss due to glue ear are not

limited to the pandemic. In fact, for some time, NICE has stressed a need for 'educational and behavioural strategies to minimise the impact of hearing loss'.³ Additionally, even when face-to-face consultations are available, the rate of non-attendance in paediatric audiology clinics is high and reflects numerous logistical factors which can limit families' access.

The Avon Longitudinal Study of Parents and Children (ALSPAC) study by Bristol University showed that glue ear disproportionately impacts children from low-income families. The Hear Glue Ear research team's absolute priority is ensuring that new technologies serve to narrow these inequalities. Importantly, the Hear Glue Ear app is free to download and requires only a stable internet connection for full access. A concern was whether some families may be limited by access to Wi-Fi, but the Department of Education's scheme providing free 4G wireless routers to some families during the lockdown is hopefully the first of some much-needed steps towards reducing this barrier for a number of families.¹² Those working in the field of paediatric audiology have the privileged role of advocating for all children with hearing loss to enable them to develop and flourish unhindered by their impaired hearing. We hope that these new innovations that have been brought to the fore during lockdown will pave the way for future remote management strategies to minimise the impact of temporary hearing loss and ultimately support children in reaching their full developmental potential.



Surina Fordington is a foundation year doctor working in Harlow. She has a strong interest in paediatrics, in particular paediatric audiology, and was involved in the development of the Hear Glue Ear app during her time at medical school.

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