



# A randomised control trial to evaluate a novel 3D animation for patient education on Menière's disease

Nikeith John<sup>1,2</sup>, Jacob Campbell<sup>1</sup>, Samuel Morris<sup>1</sup>, Payal Mukherjee<sup>1,2,3</sup>

<sup>1</sup>University of Sydney, Sydney, Australia; <sup>2</sup>Sydney Adventist Hospital, Sydney, Australia; <sup>3</sup>RPA Institute of Academic Surgery, Camperdown, Australia  
*Contributions:* (I) Conception and design: P Mukherjee, S Morris; (II) Administrative support: P Mukherjee; (III) Provision of study materials or patients: J Campbell, P Mukherjee; (IV) Collection and assembly of data: N John; (V) Data analysis and interpretation: N John, P Mukherjee; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

*Correspondence to:* Dr. Nikeith John. PO Box 1384, Wahroonga, NSW 2076, Australia. Email: nikeithj@gmail.com.

**Background:** Menière's disease (MD) is a disorder of the inner ear impacting hearing and balance. Traditionally, text-based and two-dimensional diagrammatic resources are used for patient education. In this study, we investigated if a novel 3D animation would improve patient understanding of MD.

**Methods:** A randomized single-blinded study conducted at Sydney Adventist Hospital (Tertiary Teaching Hospital) involving 40 participants without a formal prior diagnosis and no prior knowledge of MD. Participants were randomized into two groups, with control group (n=20) educated traditionally utilising two-dimensional images and a verbal explanation of MD and intervention group educated traditionally with the addition of the 3D animation (n=20). Main outcomes measured were self-reported perceived understanding of inner ear anatomy, symptomatology, pathophysiology and treatment of MD. Objectively, this understanding was quantified through the use of a quiz. Additionally, ten otolaryngologists were interviewed to evaluate the utility of the 3D animation and provide feedback regarding utility and improvement.

**Results:** There was a significant higher mean difference across aforementioned domains with 3D animation group. In addition, 100% of otolaryngologists reported the animation to be useful in explaining anatomy and disease process with MD patients.

**Conclusions:** The use of 3D animation significantly improves participants understanding of complex disease processes such as MD. It is engaging for patients and useful for clinicians.

**Keywords:** Menière's disease (MD); 3D animation; patient education; medical education; otolaryngology

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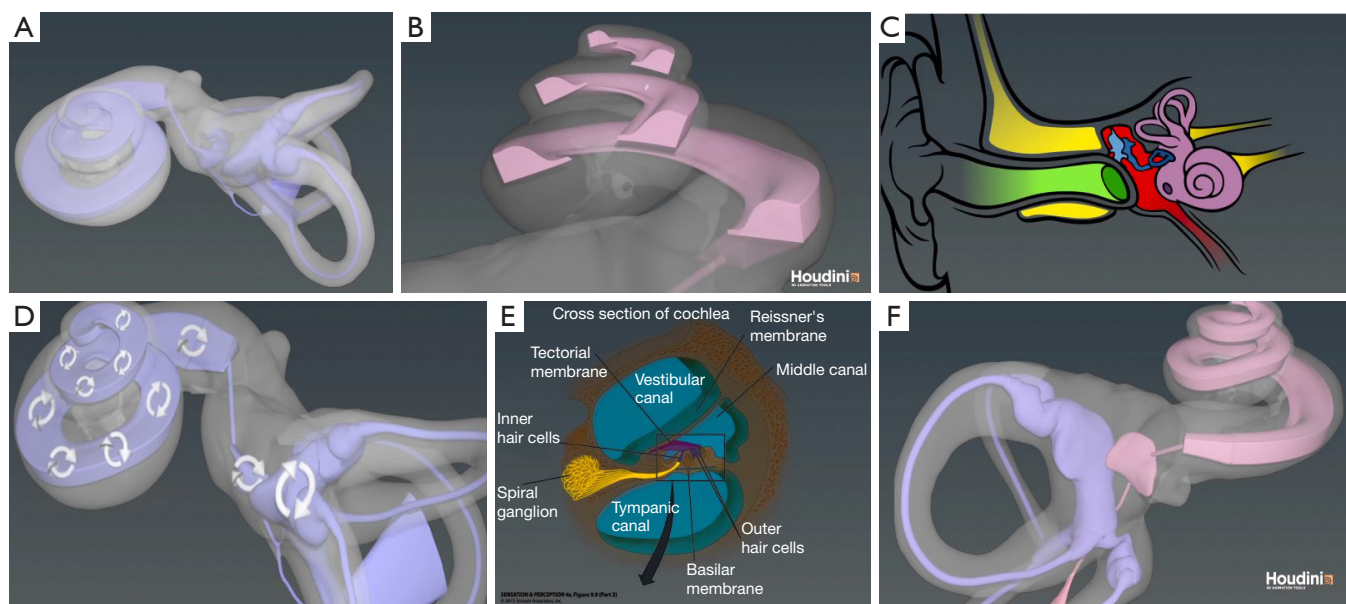
## Introduction

Menière's disease (MD) is a progressive and debilitating disease of the inner ear, impacting hearing and balance (1). Symptoms include tinnitus, vertigo, aural fullness and hearing loss (2-4). MD attacks tend to occur episodically with periods of normal inter-episodic functioning. There is however, a cumulative effect due to the damage caused during a MD attack with a significant reduction in quality of life.

The challenge with MD education is that it is dependent

on a basic understanding of the 3D anatomy and physiology of the ear. Only with this knowledge, can a patient understand the context of what is happening to their body during these disabling attacks and the proposed goals of treatment, in the context that the true aetiology of MD is still poorly understood.

Traditional education techniques involve diagrammatic representation of anatomy and physiology of the ear with someone explaining these concepts. For some patients, a two-dimensional or heavily annotated image can be challenging to visualise and comprehend what is occurring



**Figure 1** Screenshots from the animation. (A) Vestibule and cochlea. (B) Gross cross section of cochlea. (C) Sections of ear. (D) Endolymphatic flow. (E) Microscopic cross section of the cochlea. (F) Depicting symptoms.

within their body (5).

With this consideration, there is evidence that many patients with MD feel that they do not receive sufficient information from their medical practitioner, and do not feel supported by them (6,7). As a result, patients seek additional information from websites, which may be confusing, conflicting or inaccurate (6), yet effective education has been shown to be one of the most effective ways of reducing psychological stressors (1).

Whilst there is a growing body of literature demonstrating the usefulness of multimedia-based tools for patient education, there is no existing data on the use of these tools in relation to MD. Given the complex anatomy and physiology of the inner ear, the lack of knowledge of the aetiology of the disease, its disabling nature and also the significant lifestyle change of treatment and its impact on the family, there is need for better clinically driven education methods, such as multimedia-based tools.

We present the following article in accordance with the CONSORT reporting checklist.

## Methods

The primary study objective was to assess participant understanding of MD when using traditional education tools in comparison to the addition of a digital 3D

animation (*Figure 1*) with the same tools.

Human research and ethics committee approval was obtained from Adventist HealthCare Limited Human Research Ethics Committee (2017-044). This study was conducted at a single-site at the Sydney Adventist Hospital in the senior author's ENT clinic. The authors confirm that written informed consent was obtained from the patient for publication of this article and any accompanying images.

## Sample selection

Inclusion criteria was any individual over the age of 18, without prior knowledge of MD. MD patients were excluded due to several confounding variables that may affect the outcome such as hearing loss, unwellness from vertigo, tinnitus, anxiety and most importantly prior knowledge. Most patients who present to an Otologist after referral from a physician or emergency department with symptoms of MD, have often been given some information about MD (which may or may not be accurate) or have already accessed information on the internet and this prior knowledge would be difficult to standardise despite randomisation. Therefore, only healthy subjects were used in this study.

Instead, to explore disease specific challenges that the animation was anticipated to address, 10 specialist

otolaryngologists with experience in seeing Menière's patients were recruited.

They were shown the video and given a five-question survey with quantitative and qualitative feedback exploring challenges in communicating with MD patients and the value of the animation in clinical practice.

Randomisation of the participants was performed using sealed envelopes containing group allocations (either 3D animation or control) which were allocated as subjects were interviewed. There was equal probability (1:1 allocation ratio) of assignment to the 3D (test) or traditional education (control) group and each session was allocated 10 minutes.

Both groups received the same verbal information assisted with an illustrated colour diagram of the ear provided by ASOHNS (Australian Society of Otolaryngology and Head and Neck Surgery). The test group had the same aforementioned education as well as a 3D animation (approximately two minutes long) that was played on a laptop during the session. The content in both interventions was the same however, the media format was different. The session was interactive and participants were encouraged to ask questions as they arose.

Following both interventions, participants were given a post-intervention questionnaire which included qualitative and quantitative evaluation of knowledge domains. Quantitative data was measured using a five-question quiz scored as zero or one, marked out of five. Qualitative data was measured using a five-point Likert scale. Data was collected, and analysed using SPSS 25.0.

## Results

The sample consisted of 20 participants in each group (test group and control group) totaling a sample of 40 participants (17 male, 23 female) with ages ranging from 18–83 (mean age 49) (*Table 1*). Participants were blinded about the study group they were allocated to.

### Qualitative results

Cumulative qualitative scores showed a positive difference between the test and control group when looking at pre and post-intervention scores, across all three domains. This included participant understanding of MD ( $P=0.00$ ), ear anatomy ( $P=0.00$ ) and pathophysiology of MD ( $P=0.02$ ) expressing the effectiveness of the 3D animation (*Table 1*).

Additionally, there was a higher rating of the usefulness

of resource in the 3D group in comparison to the control with a statistical significance ( $P=0.04$ ) (*Table 1*). Overall, the 3D resources were found to be more effective in improving participants reported understanding of MD ( $P=0.00$ ) (*Table 1*), though overall, the value of the difference between the 2 groups was noted to be small.

### Quantitative results

This included scores of a knowledge-based quiz which was conducted in addition to the above scores of participants perceptions about their understanding. There was no statistically significant difference in the benefit of the scores between the 2 groups ( $P=0.53$ ) (*Table 1*).

### Otolaryngologist review results

Otolaryngologists were asked for feedback regarding the animation and their relevant experiences with MD patient education. Results from the questionnaire highlighted that 100% of otolaryngologists determined vertigo to be the most debilitating symptoms and also most likely to impact a patient's understanding of MD followed by anxiety (70%), hearing loss (30%) and tinnitus (10%) (*Table 2*).

When addressing the difficulties with MD education, otolaryngologists highlighted areas of difficulty being explaining the complex anatomy and pathophysiology of the inner ear as well as the concept of hydrops in MD pathophysiology and explaining the resulting correlation to their hearing and balance symptoms, which is variable in each patient. Another challenge faced by otolaryngologists was managing the impact that anxiety has on a patient's understanding of MD. It was exacerbated by the distressing nature of an acute MD attack and unclear aetiology and prognosis. Post-attack, it was identified that the significant debilitating nature of the MD attacks, lack of predictability, risk of drop attacks and the cumulative effects of MD were contributory to ongoing anxiety of MD sufferers. Of concern from the otolaryngologist's questionnaire, is that patients often seek additional information from alternative sources such as websites, which may be confusing, conflicting or inaccurate. As such, there may be misinformation of sufferers as a result of these resources.

The consensus from the survey of the otolaryngologists is that 100% of the interviewed consultants, liked the animation as they thought it clearly depicted the anatomy and physiology of the inner ear, the concept of hydrops and explained the pathophysiology of MD. Additionally, the otolaryngologists

**Table 1** Summary of mean scores in 2 groups

Domains	Group	Mean	Std. error mean	P value
Ear anatomy	Animation	5.00 (SD 0.00)	0.00	0.00
	Control	4.60 (SD 0.50)	0.11	
Pathophysiology	Animation	4.85 (SD 0.37)	0.08	0.02
	Control	4.45 (SD 0.60)	0.14	
Pt understanding (symptomatology + treatment)	Animation	13.95 (SD 1.19)	0.27	0.00
	Control	12.15 (SD 1.87)	0.42	
Rating resource	Animation	14.75 (SD 0.44)	0.10	0.00
	Control	13.60 (SD 1.60)	0.36	
Quiz	Animation	4.80 (SD 0.41)	0.092	0.53
	Control	4.70 (SD 0.57)	0.13	

**Table 2** Summary of otolaryngologists' interview results

Question category	Percentage of ENT surgeons	Average score (out of 5)
Would use tool (rated 3 or more)	100%	4
MD symptom impairing to understanding		
Anxiety (rated 4 or more)	70%	4
Vertigo	100%	5
Tinnitus	10%	3
Hearing loss	30%	3

appreciated the relatively short duration of the video (two and a half minutes) and liked that there was no backing audio as they felt that they would be able to tailor information based on the patient's background level of understanding. otolaryngologists indicated that they would use this 3D animation as part of their education tool inventory.

## Discussion

### *Choice of study content*

MD is an area of otolaryngology with complex anatomy (8,9) and pathophysiology (10). In order to understand pathophysiology and disease processes, patient's needs an understanding of the location of the inner ear, basic inner ear anatomy, audiological and vestibular physiology and then basic concepts of endolymph flow and correlation of hydrops to their symptoms.

MD patients present with a chronic burden on quality of life as a result of the unpredictability of vertiginous attacks and hearing loss (11-13) and may not be able to focus adequately or retain such information (6). Further, patient's with hearing loss may have added difficulty with verbal cues (6) and as such,

visual tools may offer a more suitable aid to understanding for these patients. These symptoms impair communication and may contribute to stress and anxiety that patients already experience by the chronic, debilitating nature of MD (11-13), further influencing control of their MD (12). This is further challenged by the limitation of time during the clinical consultation, information overload while the patient is coming to grips with the impact of the disease on their life as well as ability to recall information discussed. Debilitating symptoms and lack of clarity behind the cause often challenge doctor-patient communication (12) with literature indicating that some MD patients have found their consultation with the GP or otolaryngologist to be 'unhelpful' (6). As such, there is a need for alternative tools and adjuncts to assist with improving patient education.

### *Choice of animation*

With multimedia-based educational tools, such as 3D animations, gaining popularity in clinical practice across a variety of disciplines (14-23), it was hypothesised that such medium maybe of value to reduce barriers in doctor patient communication in MD.

An advantage of animation compared to a static picture when dealing with the MD specifically is that it can help with two important challenges: orientation and flow. Firstly, it helps patients unfamiliar with the location of the inner ear, visualise the anatomy of the membranous labyrinth in context of the overall anatomy of the ear, thus orientating the patient. Secondly, it depicts not only normal flow but also the formation and resolution of endolymphatic hydrops throughout the inner ear, thus helping the clinician correlate the patient's fluctuating auditory and vestibular symptoms with the fluctuating hydrops in the cochlea and/or vestibule or semi-circular canals. Due to the variability in presentation and fluctuation of symptoms of MD which interfaces with the dynamic nature of endolymphatic flow of the inner ear, this cannot be achieved through a static tool such a picture. Lastly, digital tools are free to access by patients, at a time and place convenient to them and this may assist in recall of information and empowers them to discuss this further with their family.

### ***Principal outcome***

This study showed that the intervention (3D animation) was effective in positively influencing participants perception of inner ear anatomy, pathophysiology of MD as well as symptomatology and treatment.

Participants from the intervention group (3D animation) reported higher levels of understanding of MD and satisfaction with the educational resource (3D animation) and accordingly, rated the resource higher compared to their control group counterparts. Importantly, the animation was reported to be more engaging by participants than static images, which was also reflected in the otolaryngologist's questionnaire.

In this study the otolaryngologists all displayed a willingness to use the animation to augment their clinical practice. The results reflected that they felt that barriers in doctor patient communication such as hearing loss, language, health literacy, anxiety, disease specific disability (vertigo and tinnitus) and time limitations can be overcome with using visual based educational resources that augment the clinical interaction. This was echoed further in the study as the clinicians expressed the value of using a 3D tool to explain a 3D concept especially in a disease that often has an unclear aetiology and prognosis with a variable course and presentation.

### ***Limitations of 3D animation study***

Although the benefits measured with the animation by

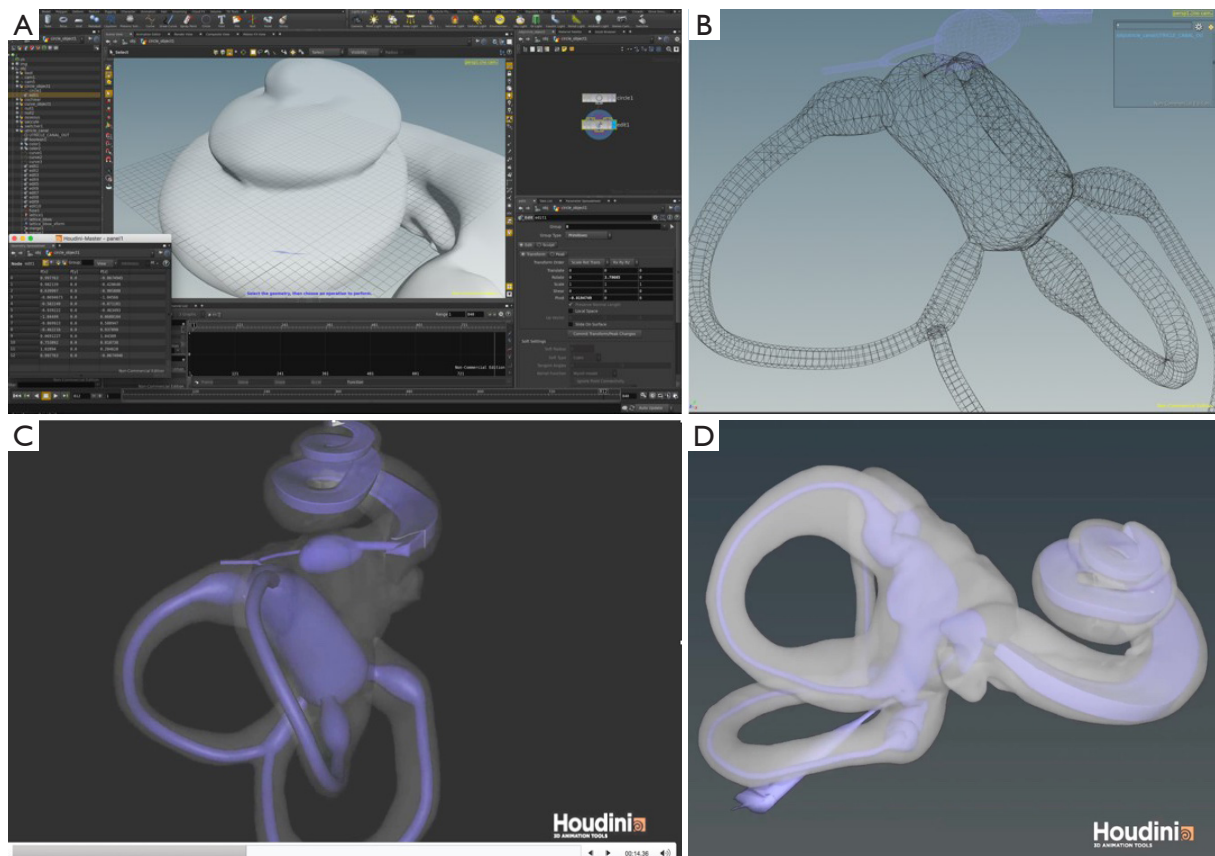
participants were statistically significant, the mean difference between the intervention and control group were small. This is most likely attributed to the fact that the sample did not involve Menière's sufferers. Patients debilitated by the disease and affected by the communication challenges such as hearing loss, anxiety, vertigo identified by the clinicians were more likely to be advantaged by the animation and thus the difference in normal healthy subjects were anticipated to be low. A low sample size (40 participants with 20 in each group) could also be attributed to this. This sample size was calculated and approved by the ethics committee as the minimum sample size that would need to be recruited to show a statistically significant difference.

When objectively testing MD understanding in both groups, there was no statistically significant correlation between self-perceived understanding of MD and the score on the quiz at the end of the session. The possible contributing factors for this include participant comprehension, age (24,25), health literacy (26), and education level (27-31) which were not controlled for. Further, due to logistical issues that would require the participants to be reviewed a second time, retention and recall of information was not tested. It would be of value to add this to future study designs, as the authors feel that this would have been of value to assess.

### ***Strengths***

Literature suggests that educational tools, such as 3D animations, have been shown to improve patient comprehension and are more helpful than verbal explanations alone. The results of this study reflected greater participant confidence in their own understanding of MD and their ability to explain this to their family members when using a 3D animation. As such, the 3D animation empowers patients and equips them with the necessary knowledge to understand MD.

It is of significance to note that this entire animation was created by a medical student (second author) as part of his University of Sydney MD project, without any formal training or background in animation. This project was made using free to use software and was created as part of a requirement that arose from a research degree and was created at no cost (*Figure 2*). The valuable contributions of this research to both doctors and patients depicts a changing topography of a rapidly evolving and highly digitally skilled junior workforce. These skills are worthy of ongoing development in the medical curriculum. In the pedagogy of



**Figure 2** constructing the animation using Houdini. (A) Smoothing out the curves of the cochlea. (B) Re-adjusting the underlying points of vestibule and cochlea obtained from microCT data for construction. (C) Preliminary construction of the vestibule and cochlea. (D) Final image of the vestibule and cochlea

medicine, knowledge and experience is traditionally passed down from senior to junior colleagues.

However, in the area of technology literacy and digital learning curve, senior colleagues should actively engage their junior colleagues and medical students in developing such digital educational platform to improve patient care. With further innovation in software development and ease of use, it is likely that such clinically driven platforms will increasingly make it easier for patients to seek reliable and accurate disease specific information.

## Conclusions

This study aimed to illustrate and evaluate the effectiveness of a novel 3D animation used for patient education on MD. The results indicated that participants preferred the 3D animation for education and had higher levels of self-reported confidence across all investigated domains of

MD. This was also reflected by otolaryngologists who reported benefit in using this tool to overcome barriers in communication with MD patients.

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## Footnote

*Conflicts of Interest:* All authors have completed the ICMJE uniform disclosure form (available at <http://dx.doi.org>).

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**Ethical Statement:** The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The trial was conducted in accordance with the Declaration of Helsinki and the Harmonized Tripartite Guideline for Good Clinical Practice from the International Conference on Harmonization. The study protocol was approved by the Adventist HealthCare Limited Human Research Ethics Committee (2017-044) and was conducted at a single-site at the Sydney Adventist Hospital in the senior author's ENT clinic. The authors confirm that written informed consent was obtained from the patient for publication of this article and any accompanying images.

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