(14)

# 智慧聽力與前瞻耳科論壇

## Smart Hearing & Advanced Otology Forum

時　　間：114 年 6 月 28 日(星期六) 08:20~12:20
地　　點：臺北榮民總醫院 長青樓會議室

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|---|---|---|
| ***08:20-08:30*** | ***Opening Remarks*** | 林奇宏教授<br>Chi-Hung Lin |
| | **座長：林峻立 教授 / 院長 (Chun-Li Lin)** | |
| 08:30-08:55 | AI 於聽覺輔具開發及應用<br>AI-Driven Design and Implementation of Hearing Assistive Technologies | 賴穎暉教授<br>Ying-Hui Lai |
| 08:55-09:20 | 人工智慧耳膜篩檢工具<br>Artificial Intelligence in Ear Drum Screening | 朱原嘉博士<br>Yuan-Chia Chu |
| 09:20-09:45 | 運用主動降噪技術實現聽檢走出聽檢室<br>Hearing Test Outsides the Booth Via the Active Noise Cancellation Technique | 鄭秀蓮博士<br>Hsiu-Lien Cheng |
| ***09:45-10:10*** | ***Coffee Break*** | |
| | **座長：曹昱 教授 (Yu Tsao)** | |
| 10:10-10:45 | 突發性耳聾：最新治療策略及成效<br>New Treatment Strategies and Outcomes for Sudden Sensorineural Hearing Loss | 廖文輝教授<br>Wen-Huei Liao |
| 10:45-11:10 | 膽脂瘤軟骨填塞術：從實驗室到臨床<br>Mastoid Cartilage Obliteration after Cholesteatoma Surgery-from Bench to Operation Room | 杜宗陽教授<br>Tzong-Yang Tu |
| 11:10-11:35 | 遺傳性聽障基因治療：從實驗室到臨床<br>Gene Therapy for Hereditary Hearing Loss—From Bench Discovery to Clinical Trial | 鄭彥甫教授<br>Yen-Fu Cheng |
| 11:35-12:00 | 穿戴式感測器於雙側前庭功能低下復健治療中的監測應用<br>Wearable Sensor Monitoring in Vestibular Rehabilitation for Bilateral Vestibular Hypofunction | 丁冠中博士<br>Kuan-Chung Ting |

# AI-driven design and implementation of hearing assistive technologies

# 基於 AI 的聽力輔助技術設計與實作

**Ying-Hui Lai**

**賴穎暉**

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*國立陽明交通大學 生物醫學工程學系*

Speech is one of the most efficient forms of human communication. But when auditory and articulation systems are compromised by conditions like sensorineural hearing loss, this ability is significantly impacted. While hearing assistive technologies, such as modern over-the-counter hearing aids (OTC HA), offer essential support, their real-world performance, particularly in complex acoustic environments and during the fitting process, presents significant challenges, limiting the full potential for improved communication.

Addressing these limitations, this talk explores the AI-driven design and implementation of next-generation hearing assistive technologies. We will demonstrate how leveraging advanced Artificial Intelligence techniques can revolutionize the core signal processing and fitting procedures within these devices.

Specifically, the presentation will delve into the application of AI in two critical areas: first, AI-Based Speech Enhancement methods (including implementation in devices like true wireless stereo headphones or OTC HA), and second, AI-Driven Automatic Real-Ear Measurement (Auto-REM) technology.

Our early results from this work are highly promising, demonstrating substantial improvements in key performance metrics for both speech enhancement quality and the accuracy/speed of Auto-REM. These findings suggest that integrating these AI-driven approaches into future hearing assistive devices holds significant potential to enhance overall user experience, communication effectiveness, and the efficiency of clinical workflows.

# Artificial intelligence in ear drum screening

# 人工智慧耳膜篩檢工具

**Yuan-Chia Chu, Yen-Chi Chen, Yen-Fu Cheng, Wen-Huei Liao**

**朱原嘉 陳彥奇 鄭彥甫 廖文輝**

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**Background:** Hearing loss prevalence dramatically increases with age, affecting over 80% of individuals above 80 years old. For general practitioners and audiologists, early identification of ear drum abnormalities is essential for timely intervention, yet traditional diagnostic tools remain limited in accessibility and ease of use.

**Methods:** We developed a smartphone-based AI application for ear drum screening that can be readily implemented in general practice settings. The system uses transfer learning algorithms through NVIDIA's framework to classify ear drum images. Our approach emphasizes user-friendly interface design specifically tailored for non-specialist clinicians and audiologists, with minimal training requirements.

**Results:** The AI system achieved 97.6% accuracy in identifying ten common middle ear conditions, making it suitable for general practice screening. Testing showed 100% sensitivity and specificity for basic hearing assessments in clinical settings.

**Conclusion:** This AI-powered ear drum screening tool offers general practitioners and audiologists an accessible method for early detection of hearing conditions without specialized equipment. The smartphone-based approach enables point-of-care diagnosis, simplifying referral decisions and improving patient care pathways. The technology represents a practical solution for incorporating advanced diagnostic capabilities into everyday clinical practice, potentially expanding the reach of hearing healthcare services.

# Hearing test outsides the booth via the active noise cancellation technique

# 運用主動降噪技術實現聽檢走出聽檢室

**Hsiu-Lien Cheng**

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**Background:** Hearing test devices have been developed in recent years. However, noise decreased the accuracy of the self-administered hearing test. Active noise cancellation (ANC) technique provides a solution but still leaves room for improvement. Herein, we designed an optimal active noise cancellation technique, based on the physiological characteristics of the auditory masking phenomenon. The study verified and validated the performance of the proposed optimizing ANC technique.

**Methods:** The experimental design comprised three parts. First, the study developed experimental equipment, including an optimizing ANC, self-administered hearing test application, and pure-tones calibrated true wireless Bluetooth headsets. Next, the ANC technique was verified in four ANC usage scenarios (normal environment, generic ANC turn off and turn on in 65 dB(A) pink noise, as the reference method), and proposed optimizing ANC turn on in 65 dB(A) pink noise). Finally, the study validated the four ANC scenarios in a clinical trial. The correlation between the ANC technique and standard audiometry was tested using Pearson correlation coefficient.

**Results:** Electroacoustic analysis showed a higher signal-to-noise ratio obtained by the optimizing ANC method compared with generic ANC turn on and turn off situation in 65 dB(A) pink noise. In addition, the clinical results showed a high correlation ($r=0.99$, $p<.01$) between the self-measured results and the professional hearing test under a < 40 dB(A) environment. In the loud noise situation (65 dB(A)), the proposed optimizing ANC method can provide a higher measurement accuracy than the reference method.

**Conclusion:** The proposed optimizing ANC method used in a self-administered hearing test showed a higher correlation to standard audiometry than to the generic ANC method.

# New treatment strategies and outcomes for sudden sensorineural hearing loss

# 突發性耳聾：最新治療策略及成效

**Wen-Huei Liao**

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**Background:** Sudden Sensorineural Hearing Loss (SSNHL) is an otologic emergency. SSNHL associated with prolonged stress, sleep deprivation, and irregular lifestyle habits. Without timely treatment, it can lead to permanent hearing loss and increase the risk of stroke within the next five years.

**Methods:** Our medical team has proposed eight innovative and integrated treatment strategies for SSNHL, aiming to improve the complete hearing recovery rate for patients:

1. **Traditional Standard Steroid Therapy:** Administering steroids intravenously to suppress inflammation in the inner ear and reduce the side effects of oral steroids.
2. **Intratympanic Steroid Injection:** For severe SSNHL cases, steroids are directly injected into the middle ear to enhance treatment efficacy.
3. **Tailor-Made Personalized Treatment Strategies:** Adjusting SSNHL patients lifestyle habits, improving sleep, and promoting weight loss based on the patient's physical condition and lifestyle.
4. **Audiogram Prediction and Treatment Adjustment Strategies:** Using big data and artificial intelligence analysis to predict SSNHL prognosis and adjust treatment plans.
5. **Innovative Hearing Scale APP:** Provides home testing features to help patients detect SSNHL early and conduct hearing tracking and monitoring.
6. **Far-Infrared Radiation Therapy:** Uses focused far-infrared radiation on the inner ear to improve cochlear microcirculation and metabolism as an adjunctive treatment.
7. **Hearing Rehabilitation Exercises:** Through deep breathing and relaxation techniques, improve SSNHL patients head and neck circulation, reduce stress, and promote blood flow to the inner ear.
8. **SSNHL Patients Education Manual:** Provides practical educational guidance for SSNHL patients, including case sharing and treatment experience summaries.

**Results:** Before the implementation of the eight innovative treatment strategies, there were a total of 1,125 hospitalized SSNHL patients, with a complete hearing recovery rate of 20.3%. After the implementation of the eight innovative treatment strategies starting from 2023, there were 106 hospitalized SSNHL patients, and the complete hearing recovery rate increased to 24.5%, an improvement of 4.2%.

**Conclusion:** Our medical team has significantly improved the complete hearing recovery rate for patients through eight innovative treatment strategies, providing a new direction for the diagnosis and treatment of SSNHL. In the future, the team will continue to optimize treatment techniques and help more patients regain the joy of hearing.

# Mastoid cartilage obliteration after cholesteatoma surgery: From bench to operation room

## 膽脂瘤乳突腔軟骨填塞手術：從實驗室研究到臨床應用

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This presentation outlines the author's personal clinical experience in managing complications associated with open mastoid cavities following cholesteatoma surgery. To prevent unsatisfactory results such as chronic drainage, recurrent infections, and the need for frequent postoperative care, small pieces of autologous cartilage harvested from the conchal area of the same ear were used to obliterate the mastoid cavity. These pieces were typically trimmed to a size of 1–1.5 $mm^3$ before obliteration.

The author will demonstrate the general surgical procedure as well as the specialized techniques for preparing and applying the conchal cartilage. In most cases, cartilage harvested from the operated ear is sufficient to obliterate sclerotic or moderately sized cavities. However, for larger, well-aerated mastoid cavities, additional techniques may be required to achieve ideal obliteration.

In experimental studies using a rabbit model, the author investigated the biological behavior of auricular cartilage obliterated into the tympanic bulla (the rabbit equivalent of the human mastoid). Two significant effects were observed:

1. **Space-occupying effect –** the cartilage effectively fills the entire cavity, eliminating dead space and reducing the risk of infection.
2. **Osteochondral regeneration effect –** the perichondrium stimulates the regeneration of bone tissue within the cavity.

This regenerative phenomenon was also observed in postoperative CT scans of the patients, confirming the cartilage's potential to contribute to bone repair. This property is particularly valuable in those patients with skull base defects caused by cholesteatoma invasion, as it helps prevent the development of meningocele, brain herniation, and intracranial infections or abscesses.

A common concern is whether the cartilage may undergo atrophy, necrosis, or volume loss due to infection or inadequate blood supply over time. To investigate this, the author conducted a retrospective review of 102 patients who underwent cartilage obliteration between 1997 and 2007, with a mean follow-up period of 8.8 years. The findings revealed that approximately 10% of patients experienced short- or long-term complications, including cartilage infection, resorption, or poor epithelialization of the canal and cavity wall. Multivariate logistic regression analysis identified revision surgery and poor preoperative middle ear conditions as significant risk factors for these unsatisfactory outcomes.

Despite these exceptions, the majority of patients maintained a stable, non-resorbed, and complication-free cartilage-filled mastoid cavity over the long term.

# Gene therapy for hereditary hearing loss: From bench discovery to clinical trial

# 遺傳性聽障的基因療法：從實驗室到臨床

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Hereditary hearing loss—the most prevalent congenital sensory disorder, affecting 1–2 per 1 000 newborns—is exceptionally well-suited to precision therapeutics. The cochlea is surgically accessible, fluid-sealed, and >50 % of cases stem from single-gene defects. Over the past decade, breakthroughs in inner-ear biology have converged with state-of-the-art gene-delivery and editing technologies. Engineered adeno-associated virus (AAV) capsids such as Anc80L65 and evolved AAV9 variants now achieve >80 % inner-hair-cell transduction in rodents and non-human primates, while hybrid lipid–polymer nanoparticles accommodate oversized or dual-vector genomes. In parallel, CRISPR-based base and prime editors, together with antisense-oligonucleotide exon repair, have expanded the therapeutic arsenal beyond classical gene replacement.

These innovations are translating into clinical reality: global phase I/II trials are underway for OTOF (auditory synaptopathy), with preliminary safety readouts showing no dose-limiting ototoxicity. Our team has contributed key pre-clinical milestones, including some of the most common forms of hereditary hearing loss

Looking ahead, the implementation of universal newborn genomic screening, mutation-matched vector design, and scalable GMP manufacturing will dictate the speed at which these therapies reach patients. By integrating molecular genetics, vectorology, and clinical otology, gene therapy is poised to redefine the management of genetic deafness within the coming decade.

# Wearable sensor monitoring in vestibular rehabilitation for bilateral vestibulopathy

# 穿戴式感測器於雙側前庭功能低下復健治療中的監測應用

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**Background:** Bilateral vestibulopathy (BVP) causes chronic dizziness, impaired gaze stability, and balance deficits, significantly impacting daily function. Although vestibular rehabilitation therapy (VRT) is recommended, objective and quantitative tools for monitoring therapeutic progress remain limited..

**Methods:** Patients diagnosed with BVP and experiencing chronic dizziness for over six months participated in a structured 3-month VRT program. Assessments were conducted monthly. Wearable inertial measurement units (IMUs) were used to capture head and body motion. A custom algorithm was applied, combining gaze stability monitoring based on Madgwick's decomposition and balance evaluation through 122 sway-related features. Subjective symptoms were assessed using the Dizziness Handicap Inventory (DHI).

**Results:** IMUs accurately measured head motion range and postural sway, providing objective feedback during training. Progressive improvements in gaze control accuracy and postural stability were observed over time. These objective findings were consistent with improved DHI scores, reflecting symptom relief.

**Conclusion:** This study highlights the effectiveness of wearable sensors in objectively tracking rehabilitation progress in BVP patients. The integration of motion-based algorithms and subjective assessment supports the advancement of personalized, data-driven vestibular rehabilitation strategies.