Development of a Rapid Point-of-Care Diagnostic Kit for Differentiating CSF rhinorrhea from Benign Nasal Discharge

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Background

Accurate differentiation between cerebrospinal fluid (CSF) and benign nasal secretions is a clinically important yet persistent challenge in multiple settings, including postoperative care after endoscopic endonasal skull base surgery and evaluation after traumatic skull base injury. Current diagnostic approaches—most commonly laboratory-based β2-transferrin assays and adjunctive tests such as glucose concentration analysis—are used in practice to support confirmation of CSF. However, these methods are limited by cost, delayed turnaround times, and variable diagnostic performance across different sample conditions and clinical contexts. As a result, timely decision-making may be hindered when rapid confirmation is needed.

Objective

This study aims to develop a **rapid point-of-care (POC) diagnostic kit** that can reliably identify CSF in nasal discharge. The project will (1) **screen and prioritize clinically relevant biomarker candidates** and (2) **evaluate their suitability for integration into a practical detection platform** designed for use across high-need clinical pathways. This early-stage effort is built on a multidisciplinary collaboration among **neurosurgery, otolaryngology (ENT), and materials science**, aligning real-world clinical requirements with biosensor/platform feasibility from the outset.

Methods and Materials

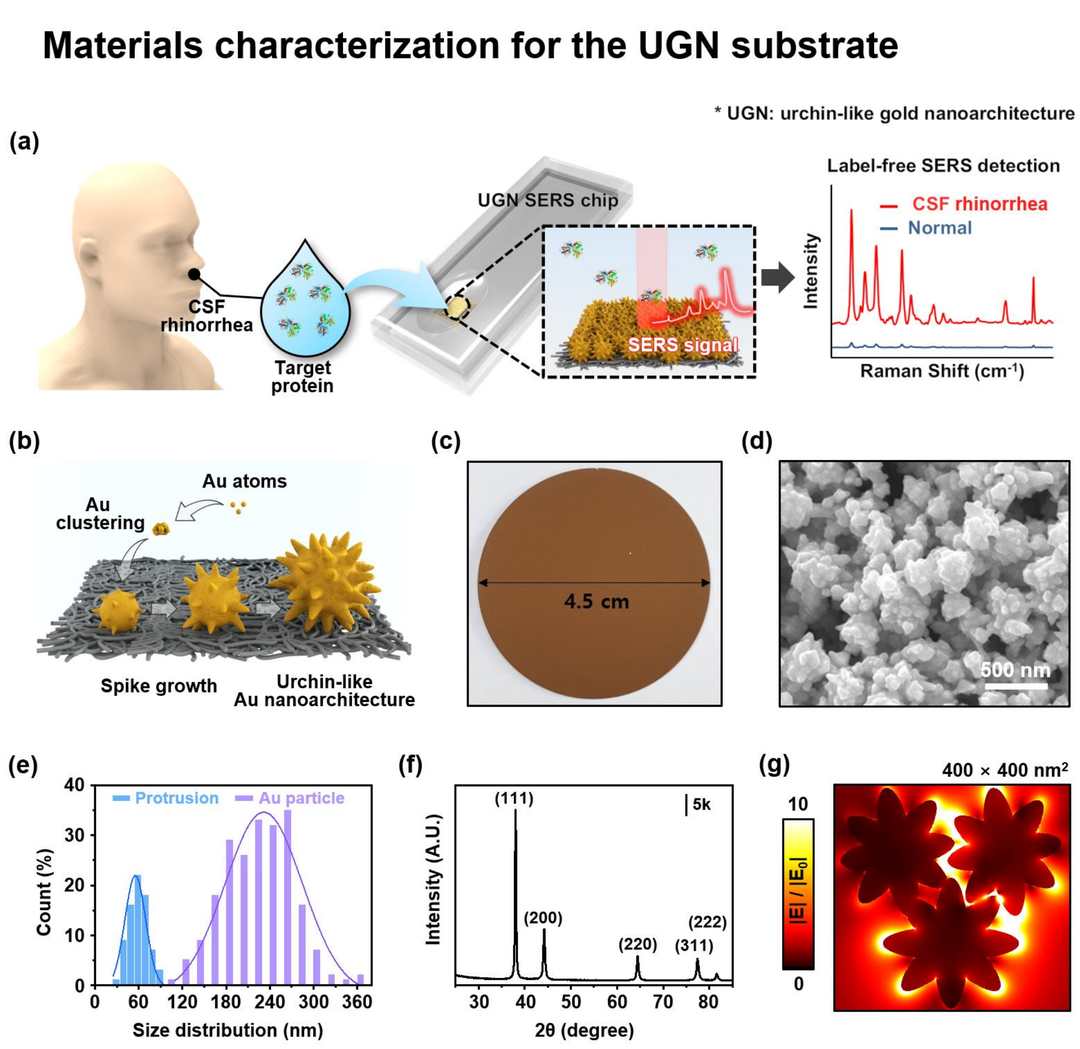

Figure 1. Materials characterization for the UGN substrate. (a) Schematic diagram of the plasmonic sensing platform for CSF rhinorrhea diagnostics. (b) The formation mechanism of the UGN. (c) photograph of the synthesized UGN substrate. (d) SEM image of the UGN. (e) The particle and protrusion size distribution of the UGN, (f) XRD spectrum showing polycrystalline structure. (g) FDTD simulation to find E-field distribution.

Results

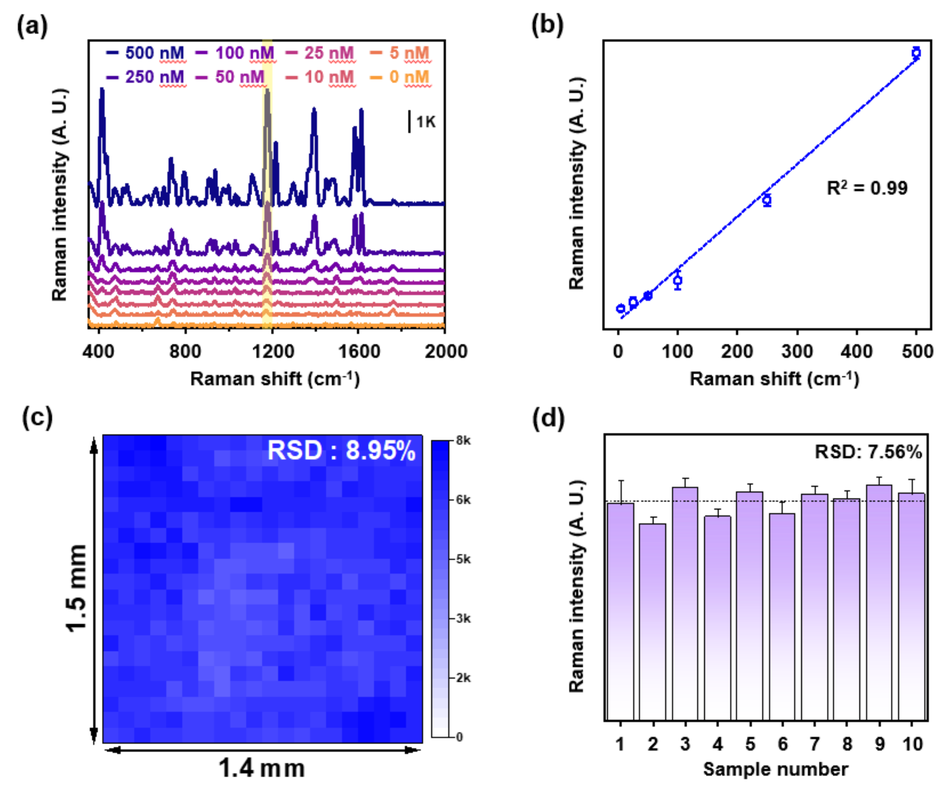

Figure 2. Plasmonic properties and SERS performance of the UGN sensor. (a) SERS performance and (b) standard curve of the UGN sensor at various MG concentrations under 785 nm excitations. (c) signal uniformity test at 400 different points. (d) reproducibility test with ten different UGN substrates.

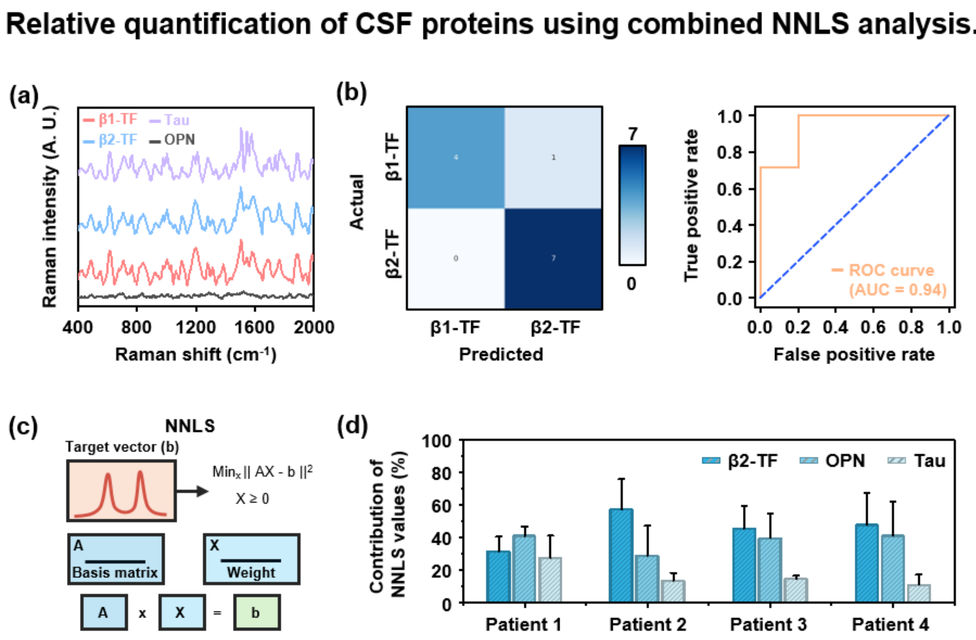

Figure 3. Machine learning-based classification and mathematical modeling for biomarker quantification. (a) SERS spectra of individual biomarkers: β1-transfferin (β1-TF), β2-transfferin (β2-TF), Osteopontin (OPN), and Tau protein. (b) ROC curve and confusion matrix showing the classification performance between β1-TF and β2-TF proteins. (c) Schematic diagram of the Non-negative Least Squares (NNLS)-based mathematical modeling for signal deconvolution. (d) Comparison of NNLS-derived relative contributions of β2-TF, OPN, and Tau proteins for four representative patients.

Conclusions

This early-stage, multidisciplinary project addresses a well-recognized clinical gap in the diagnosis of CSF rhinorrhea. By integrating clinical insight from neurosurgery and otolaryngology with materials science–based diagnostic development, this study aims to lay the groundwork for a rapid, practical POC diagnostic kit. Further biomarker validation and clinical testing will be essential steps toward improving clinical decision making and patient safety in skull base surgery and CSF leak management.

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