Experimental Evaluation of Soft Gasket Seal Reconstruction in Dural Defect Models: Anterior and Posterior Fossa Simulations

Rodrigo D. Gehrke[1], Federico Valeri[2], Je Beom Hong[2], Kara A. Parikh[2], Moataz D. Abouammo[1], Francis Lorraine-Miller[1], Yongli Wang[1], Rebecca Leme Gallardo[1], Ricardo L. Carrau[1], Daniel M. Prevedello[2]

[1] Department of Otolaryngology/Head and Neck Surgery, The Ohio State University Wexner Medical Center, Columbus, Ohio, USA

[2] Department of Neurosurgery, The Ohio State University Wexner Medical Center, Columbus, Ohio, USA Department of Otolaryngology/Head and Neck Surgery

THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER

Introduction

Cerebrospinal fluid (CSF) leakage remains one of the most clinically significant complications following skull base surgery, particularly in cases involving large dural defects or posterior fossa exposure. Although soft gasket seal reconstruction has been proposed as a technique to improve resistance to CSF leakage, its effectiveness has not been systematically validated in controlled experimental settings. This study aimed to evaluate the leakage-preventing effect of soft gasket seal reconstruction compared with conventional inlay grafting using standardized dural defect models simulating anterior and posterior fossa conditions.

Methods

Standardized dural defects ranging from 5 to 30 mm in diameter were created in experimental models. Two reconstruction strategies were evaluated: conventional inlay graft reconstruction and soft gasket seal reconstruction. To simulate anatomical differences between skull base regions, defect surfaces were positioned either horizontally (anterior fossa simulation) or in a tilted orientation (posterior fossa simulation). Leakage was quantified by measuring the volume of fluid collected over a 30-second interval. Total leakage volumes and calculated flow rates (mL/min) were analyzed across defect sizes, reconstruction types, and orientation conditions.

Results

Leakage volume increased progressively with defect size across all experimental models. Conventional inlay graft reconstruction demonstrated limited resistance in larger defects, with uncontrolled outflow exceeding measurable limits at defect diameters ≥25 mm. Specifically, inlay graft failure resulted in outflow volumes >200 mL/30 seconds, corresponding to flow rates >400 mL/min, under both horizontal and tilted orientations. In contrast, soft gasket seal reconstruction consistently reduced leakage across all defect sizes and experimental conditions. The protective effect of the gasket seal technique was most pronounced in medium-sized defects, where it delayed the onset of uncontrolled leakage. Orientation influenced leakage primarily in small defects, with tilted positioning producing greater leakage compared with the flat condition. In larger defects, defect size was the dominant determinant of leakage, and positional differences became minimal. Importantly, the protective benefit of soft gasket seal reconstruction was reproducible across both anterior and posterior fossa simulations.

Fig.1 Skull Base Defects in Anterior and Posterior Fossae

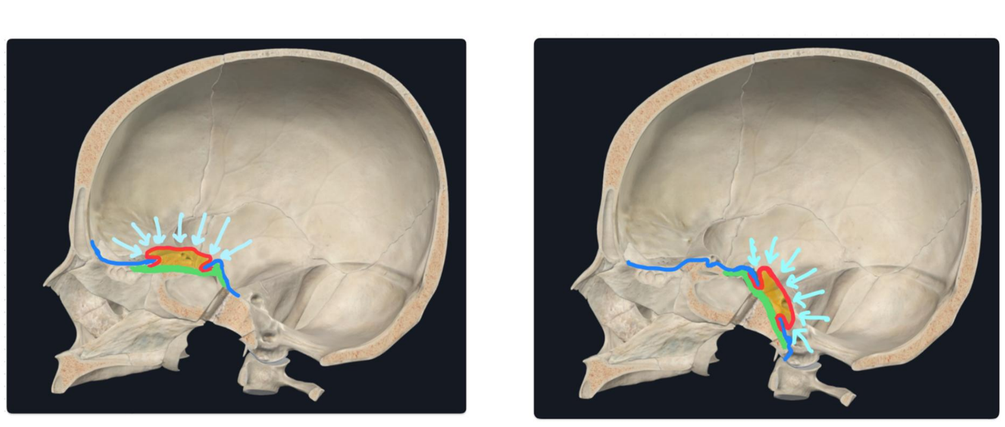
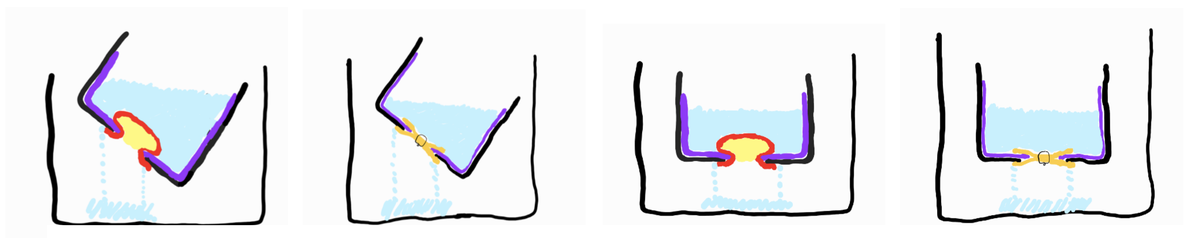
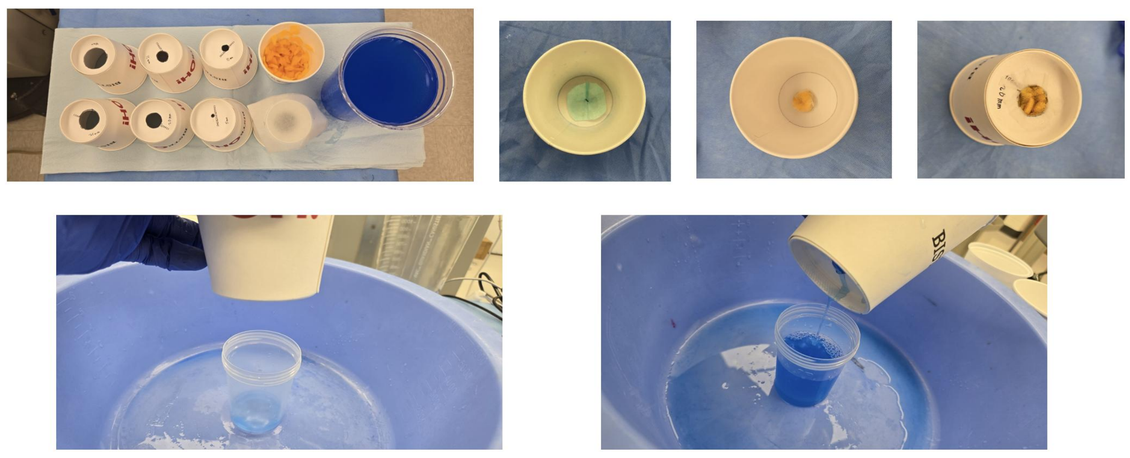
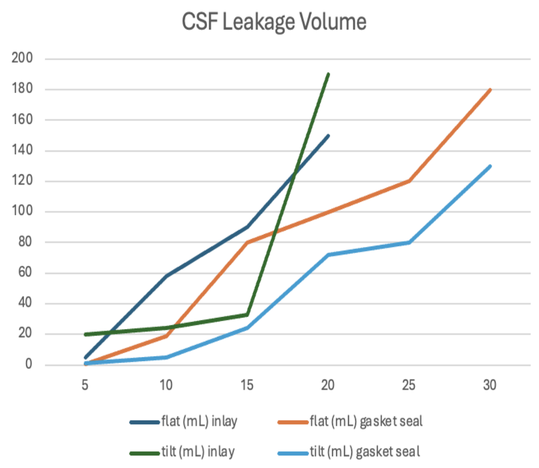


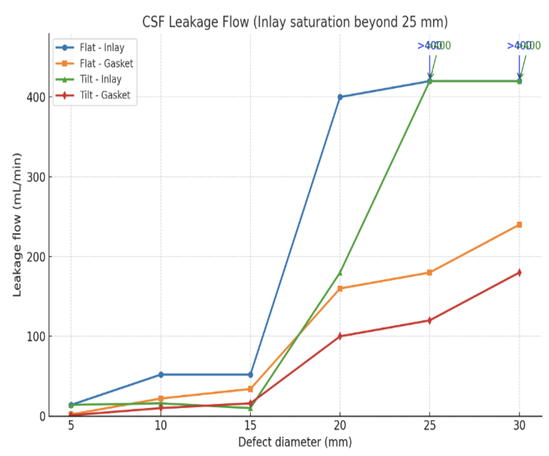
Fig 2. Skull Base Defect Reconstruction Simulation Model



Simulation Model







Conclusion

This simulation-based experimental study demonstrated that soft gasket seal reconstruction provides substantially greater resistance to CSF leakage than conventional inlay graft reconstruction across a broad range of dural defect sizes. The gasket seal technique reduced leakage and maintained efficacy under both anterior and posterior fossa model conditions. These findings support the soft gasket seal technique as a reliable reconstruction strategy for dural defect repair in skull base surgery, particularly in larger defects where conventional inlay grafting may fail rapidly.