Utility of Advanced Visualization in Intracerebral Arteriovenous Malformation Management

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1. Introduction

Navigating the complexities of cerebrovascular disorders such as intracerebral arteriovenous malformations (iAVMs) necessitates cutting-edge diagnostic and therapeutic modalities. Advanced Visualization (AV) technologies, particularly three-dimensional (3D) rendering, are emerging as invaluable assets that could revolutionize clinical practice by offering enhanced insights and operational efficiencies. This pilot study is designed to critically assess the impact, utility, and transformative potential of AV models in the hands of staff physicians managing iAVMs. With a focus on quantifiable metrics and qualitative evaluations, we aim to elucidate the multidimensional benefits that AV models can bring to this intricate area of medicine.

2. Methods

The visualization process combines engineering and clinical expertise to create personalized AV models. Using Electronic Health Records (EHR), a wide range of metrics related to case utilization and epidemiology were captured. The Materialise® Innovation Suite was employed to transform DICOM data into high-fidelity 3D models. This process involves collaborative efforts between biomedical engineers and clinicians, like radiologists and neurologists, ensuring both technical and clinical accuracy. These 3D models are then made accessible to medical professionals through a user-friendly, web-based viewer, enhancing diagnostic and treatment strategies. Clinician feedback is collected systematically via REDCap surveys and analysed using robust statistical methods in R programming. Overall, the methodology offers a comprehensive view of the utility and impact of integrating 3D-printed AV models in medical practice, both quantitatively and qualitatively.

3. Results

In our study, AV models proved to be a significant asset in clinical decision-making compared to traditional 2D imaging. Specifically, staff-level physicians found that AV models enhanced their diagnostic capabilities in 48% of cases (n=12) and aided in procedural planning in 32% of cases (n=8). Additionally, they provided procedural confirmation in 20% of instances (n=5). Furthermore, these models allowed clinicians to identify novel normal anatomy in 49% of cases (n=25) and abnormal anatomy in 45.1% of cases (n=23) that were not apparent in 2D imaging. The impact extended to changing the staff's diagnosis in 13.7% of cases (n=7) and altering the therapeutic approach in 45.1% of cases (n=23). These findings underscore the transformative potential of AV models in enhancing diagnostics, treatment planning, and procedural confirmations, while often revealing critical anatomical details otherwise missed in traditional imaging methods.

4. Discussion

This pilot study offers a quantifiable assessment of the role of arteriovenous (AV) models in the diagnosis and treatment of complex cerebrovascular conditions. Our investigation substantiates the improved clinical acumen offered by these 3D models compared to traditional 2D imaging techniques. Notably, our findings indicate a pronounced impact of AV models on key aspects of clinical decision-making, ranging from diagnostics to treatment planning and procedural confirmation. The study also brings to light the untapped potential for revealing critical anatomical details that conventional methods might overlook. These results emphasize the imperative for expanded research into the applicability of AV models across a broader spectrum of neurological disorders.

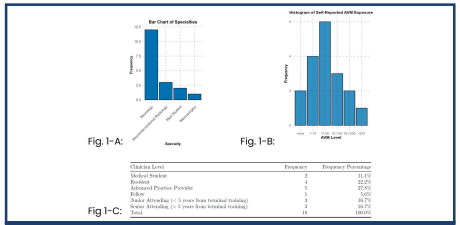

Figure 1: Overview of Clinician Survey Participants: (A) Bar Chart Representing Specialties Distribution, (B) Histogram Showcasing Self-Reported Exposure to AVM Cases, and (C) Summary Statistics Illustrating Clinician Experience Levels.

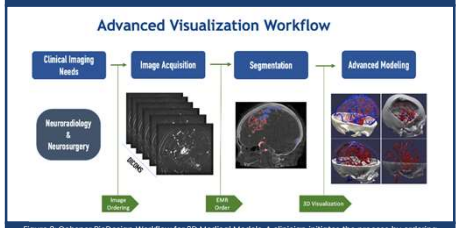

Figure 2: Ochsner BioDesign Workflow for 3D Medical Models. A clinician initiates the process by ordering through the Electronic Medical Record. DICOM data is then securely accessed from an enterprise PACS. Biomedical Engineers use CAD software to transform this data into 3D files, which can be viewed via a web interface or extended reality (XR) technologies. These 3D models are ultimately materialized through 3D printing.

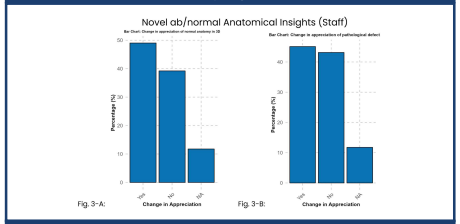

Figure 3: Impact of Advanced Visualization on Clinical Decision- making: (A) Bar Chart Demonstrating Changes in Diagnosis Post-AV Model Utilization, and (B) Bar Chart Highlighting Alterations in Therapeutic Procedures following AV Model Application.

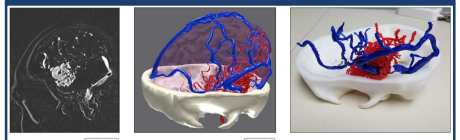

Figure 4: Comparison of Visualization Methods for Arteriovenous Malformations with (A) Axial Series from Source Angiography with QR code showing the series video, (B) Digital 3D Model with the QR code rendering an on-screen and AR model, and (C) 3D Printed Physical Model.

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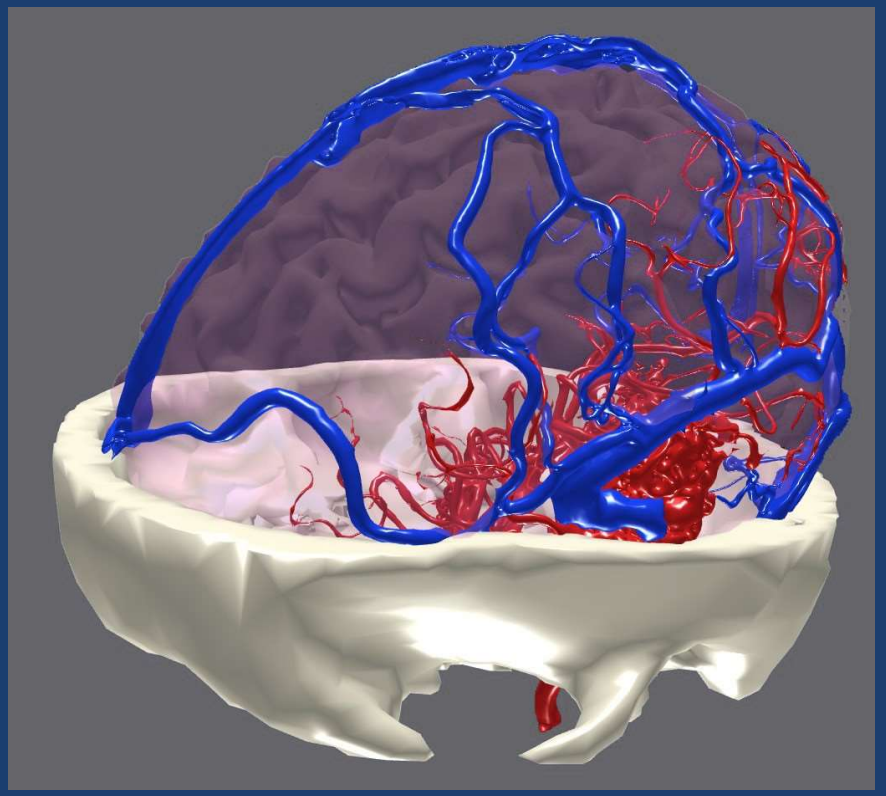
3D Visualization Enhances Clinical Decision-Making and Management of Arteriovenous Malformations: Unlocking New Avenues for Improved Patient Care



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