Automated Head Positioning to Optimize Biplane C-Arm Projections in Intracranial Aneurysm Treatment

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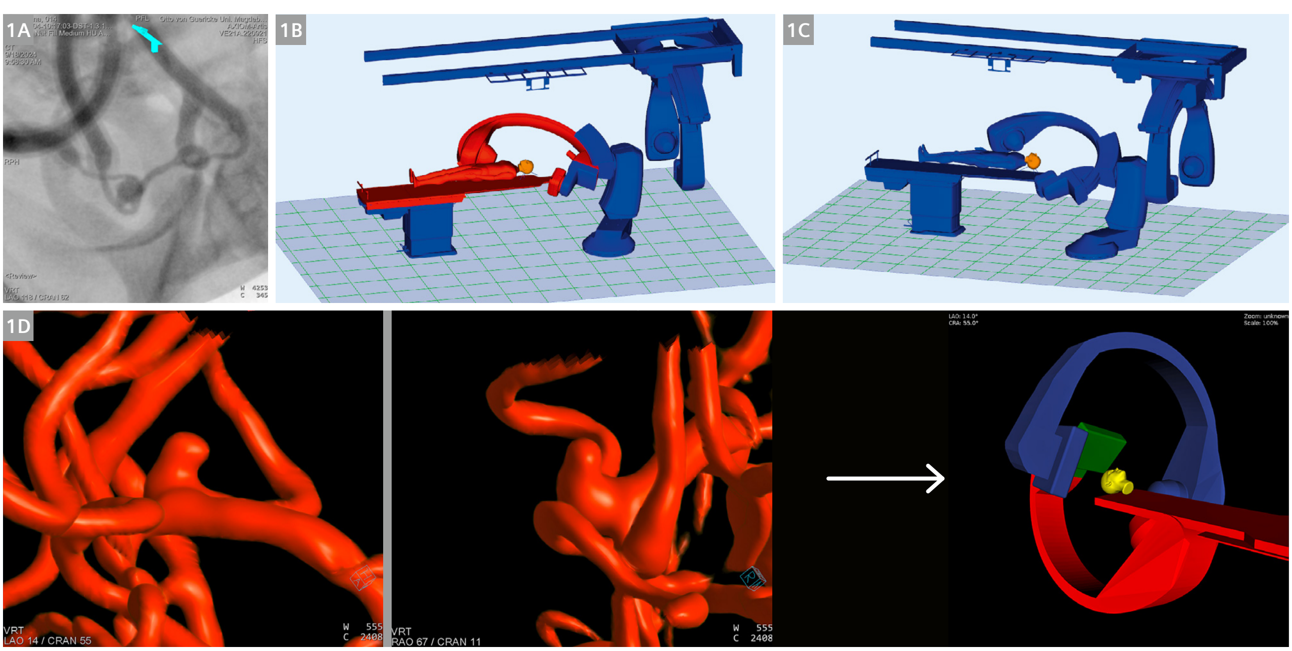
Introduction

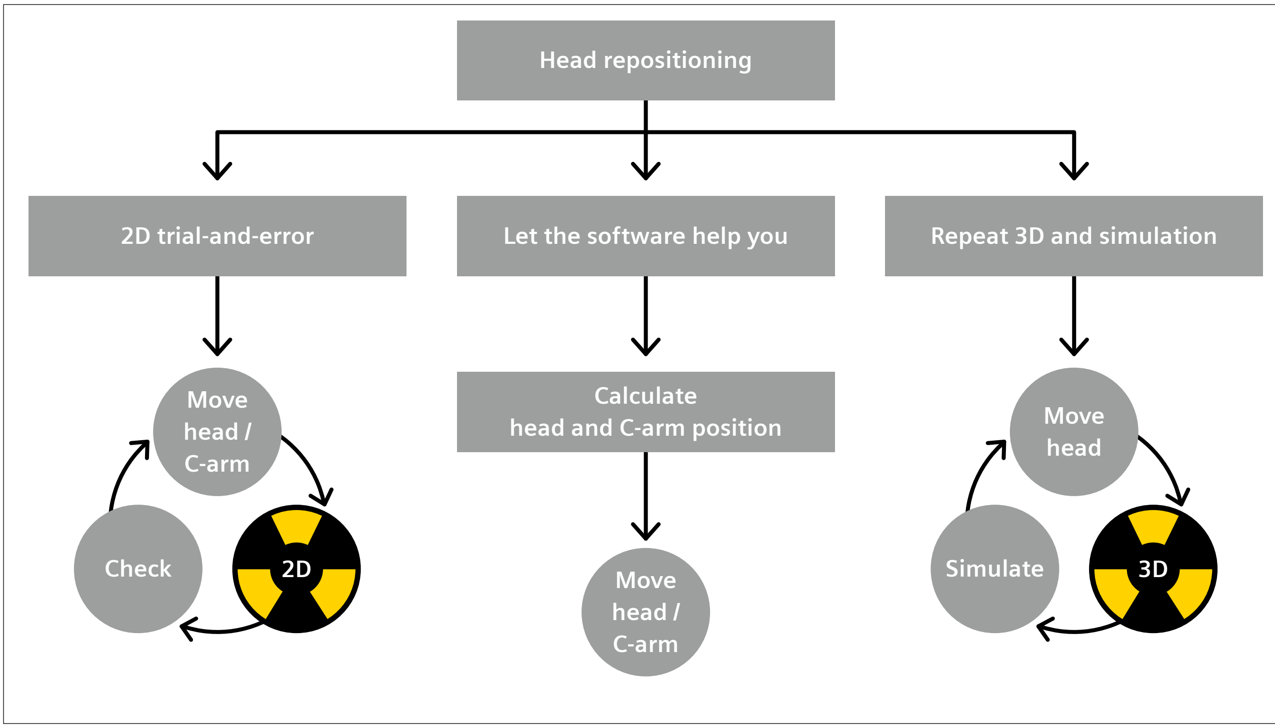
The endovascular treatment of intracranial aneurysms has become a standard therapeutic option over the past three decades. Its success is closely linked to the quality of angiographic imaging, which not only enables diagnosis and procedural planning, but also provides the real-time guidance necessary for safe device deployment. Optimal imaging in this context does not merely mean standard anterior-posterior (AP) or lateral projections, but rather the identification of individualized "working projections" that provide unobstructed visualization of the aneurysm sac, the neck, and the parent vessels.

Traditionally, such projections were identified empirically, often requiring multiple 2D acquisitions in a trial-and-error fashion. The introduction of 3D rotational angiography and 3D digital subtraction angiography (3D-DSA) has dramatically improved this process, allowing operators to plan projections on volumetric datasets before attempting them in the angiography suite. However, a persistent limitation remains: the mechanical restrictions of C-arm systems.

When an operator selects the theoretically optimal projection, it may not be physically achievable because of collision risks with the patient or the angiography table. This mismatch between imaging theory and clinical reality is a frequent bottleneck in neurointerventions. In some cases, it forces the use of suboptimal views, with potential consequences for device safety and procedural efficiency. In extreme cases, it may render an intended endovascular treatment technically impossible.



1 **(1A)** 3D display showing a perspective translucent mock rendering of a DSA scene. Users may select the optimal projection here. **(1B)** Simulation tool showing a collision issue with the selected ARTIS icono device angulation. **(1C)** Proposed solution, involving Head Movement and an attainable alternate angulation. **(1D)** The optimal projection for an MCA bifurcation aneurysm would cause a collision between the C-arm and the patient table.



2 Possible workflows for finding optimal working projections using (left) the traditional 2D-DSA trial-and-error method, (right) the repeated use of 3D-DSA and simulation, and (center) the one-time 3D-DSA and head-orientation simulation approach described in this article.

To address this gap, researchers at University Hospital Magdeburg have developed a prototype solution: automated calculation of optimized head positions[1]. By adjusting the orientation of the patient's head, the anatomical relationship between the intracranial vessels and the C-arm geometry can be modified, creating feasible working projections that would otherwise be unattainable.

In close cooperation with Siemens Healthineers, the original prototype[1] is in the process of being further developed into an integrated solution with existing Siemens Healthineers angiography devices like the ARTIS icono or the ARTIS pheno.

Methods

The prototype software uses volumetric angiographic data as input. Based on operator-defined target projections, it calculates the C-arm angulations that would provide the desired view of the aneurysm. If these angulations are not feasible due to collision risks, the system simulates potential head repositioning maneuvers and determines new C-arm orientations that preserve the aneurysm visualization while avoiding collisions.

The software supports combined movements along three axes: flexion/extension (± 30°), lateral tilt (± 30°), and rotation around the longitudinal axis (implemented but rarely required). The algorithm prioritizes solutions that minimize the extent of head movement required, preserving patient comfort and procedural workflow. Once an optimized head position is determined, the software outputs the necessary head angles and the corresponding new C-arm coordinates.

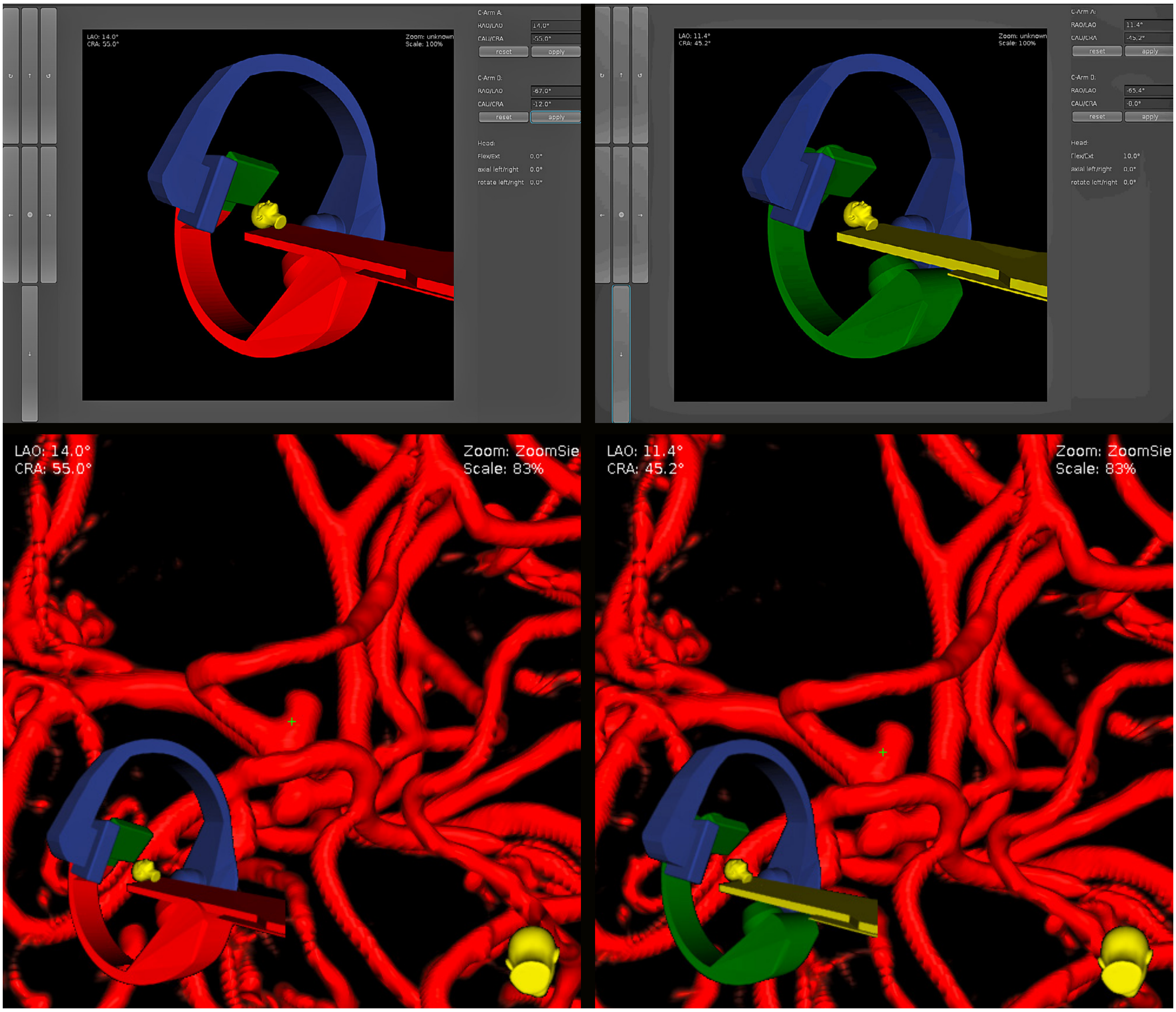
Validation was performed in vitro on 20 cases of anterior circulation aneurysms. Five experienced interventional neuroradiologists independently selected optimal working projections on a simulation platform, disregarding mechanical restrictions. This process yielded 100 candidate biplane working projections. Each candidate projection was then analyzed by the prototype.

Results

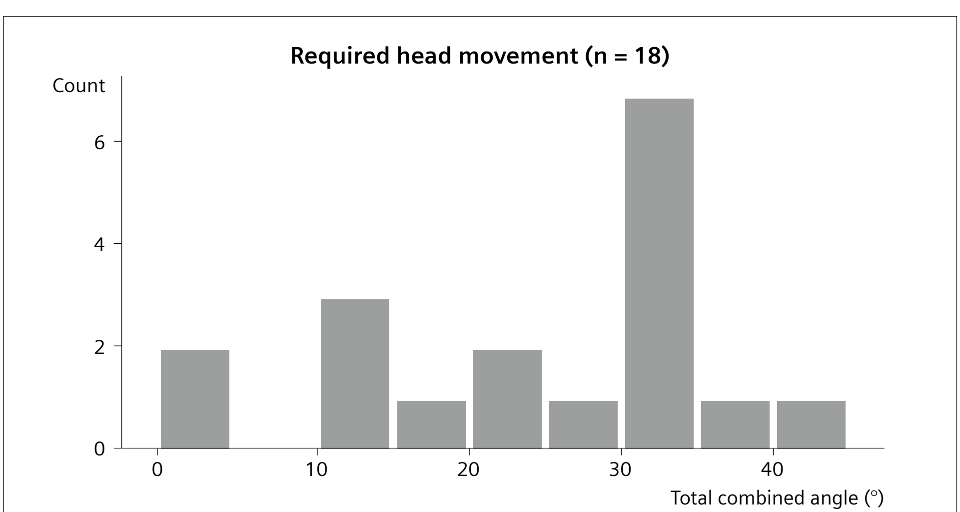
Of the 100 candidate projections, 18 were not feasible on a real angiography system because of collision risks, primarily between the C-arm and the angiography table. In all 18 cases, the optimization tool successfully calculated head orientations that resolved the collisions while maintaining the desired aneurysm view.

The required adjustments were modest: In several cases, a flexion or extension of only 10° was sufficient.

[1] *Work in progress. The application is currently under development and is not for sale in the U.S. and in other countries. Its future availability cannot be ensured.*



3 Example case showing an MCA bifurcation aneurysm in C-arm A projection before **(left)** and after **(right)** 10° flexion optimization.



4 Required head-orientation adjustments in degrees.

Importantly, all optimized projections could be reproduced on the angiography system in vitro, confirming the feasibility of the approach.

This finding highlights two key aspects: First, that head repositioning can systematically expand the range of achievable projections. Second, that the extent of movement required is small enough to be practical in real clinical conditions, even in patients under general anesthesia.

Supplementary analyses included visualizing the algorithm's calculated head-angle adjustments, examining consistency across operators, and reproducing the calculated C-arm positions on the angiography system. Across all operators, the tool demonstrated high reliability in identifying feasible solutions.

Discussion

This study demonstrates that automated head positioning can close the gap between theoretical planning and practical execution in neurointerventional imaging. By shifting the anatomical frame of reference through modest head movements, operators can access projections that would otherwise be excluded due to system collisions.

The clinical benefits of such a solution are substantial. First, it may reduce reliance on suboptimal views, which often compromise visualization of the aneurysm neck and parent vessel. Improved visualization can translate directly into safer and more effective device deployment, particularly for stent-assisted coiling or flow diverter placement. Second, it may shorten procedure time by reducing the need for repeated 3D acquisitions. Third, it may expand the treatability of certain aneurysm cases that would otherwise be deemed unsuitable for endovascular therapy.

At the same time, several important limitations and questions remain. The feasibility of specific head movements in real patients, especially in combination, is not well characterized in the literature. The required precision of head orientation to replicate the simulated working projection also requires systematic evaluation. Ergonomic aspects, including airway management and anesthesia safety, must be carefully considered before clinical implementation. Finally, it remains to be tested whether real-time feedback on head positioning can be seamlessly integrated into workflows without prolonging procedures.

Comparison with the existing literature underscores the novelty of this approach. While anecdotal reports describe manual head repositioning to improve projections, this is the first systematic, software-assisted framework for doing so. Early in vitro validation provides strong feasibility data, but prospective clinical trials will be required to determine the true impact on safety and outcomes.

Conclusion

Automated head positioning represents a promising new dimension of procedural planning in neurointerventions. By systematically leveraging patient head orientation to resolve C-arm collision issues, it may expand the range of feasible working projections, improve visualization, and enable safer and more efficient aneurysm treatments.

The prototype developed at University Hospital Magdeburg in cooperation with Siemens Healthineers demonstrates that such solutions are technically feasible and reproducible. With further clinical validation, automated head positioning could become an integral part of neurointerventional workflows, bridging the gap between theoretical planning and clinical reality.

References

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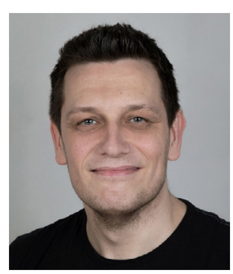

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