

# Application of Computer-aided Image Reconstruction and Image Guild in Parasagittal Meningioma Resection

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## Research

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# Abstract

## Background

In recent years, due to increased cranial imaging more and more small sized (diameter <2.5cm) meningiomas are diagnosed. If symptomatic then most of them need surgical removal. Exact location of the lesion is extremely important to tailor the craniotomy especially if the neuro-navigation system is not available. Many under developed countries cannot afford high costs of neuro-navigation. Hence, is relevant to discover low cost associated and effective methods to exactly locate the lesions for the surgery.

## Methods

By using localization markers, we can acquire preoperative CT images of the patients, reconstruct these images into Three Dimensional (3D) virtual graphs using a computer, measure the spatial distance of the tumor from the markers, and in turn calculate the projection location of the tumor on the scalp by the Triangle Pythagorean theorem. Thereby achieving preoperative precise localization of intracranial microlesions.

## Results

The location of the tumor was consistent with that of the preoperative virtual image, and the craniotomy was exact. The patient was discharged 3 days later without any neurological deficits.

## Conclusion

This method is simple and reliable, inexpensive, and accurate in location of small sized lesion, which can partially compensate lack of neuro-navigation and is suitable for widespread application in hospitals in third world countries.

## Introduction

Meningiomas are common intracranial tumors, incidence rate is only inferior to gliomas, ranking second in intracranial tumors. The most common growth area of meningiomas is parafalx or parasagittal sinus, accounting for 19.5-45% of intracranial meningiomas [1]. With the popularization of Computed tomography (CT) and Magnetic Resonance (MR), more and more small meningiomas (less than 2.5cm in diameter) have been diagnosed, and some patients require active surgical treatment. Surgical resection and location of parasagittal meningioma is still challenging, especially when the tumor size is small, it is still difficult to accurately locate the tumor to keep the size of craniotomy small. The application of neuronavigation is an ideal option, but many hospitals especially in third world countries are still not equipped with it. This work introduces a method of CT image reconstruction using open source software for preoperative tumor localization and plan the craniotomy exactly.

# Methods

Here we present a case of small parasagittal meningioma and show the protocol to exactly locate small parasagittal meningioma without neuronavigation.

**Case description:** Here we present a case of 58-year-old female patient with small parasagittal meningioma that was found in a routine health check. She was under great mental stress and therefore she wished for surgical treatment. Medical examination showed no neurological deficits and her general health condition was good.

Pre-operative MRI showed a parasagittal meningioma (Fig. 1) with a 2 cm in diameter.

Preoperative preparation, tumor location, and operation process: 1 day before the operation, after skin preparation of the head, mark the median sagittal line. According to MR, after roughly locating the tumor, two electrodes were pasted on the front and back of the tumor respectively, and the marked position was used as a reference. The DICOM file was obtained after thin-layer CT scanning of the head. The CT images of the tumor and the reference material data were obtained (Fig. 2). By importing the data into the computer and running the 3D-slicer software. The 3D model of the tumor and electrode slices was reconstructed by using the Editor Tool. The spatial relationship of the three points (mark A mark B and tumor C) can be observed on the screen (Fig. 3). Then run the volume reading tool to get the whole head model. Select CT-Fat sequence to make the model transparent. By this time we can observe the relationship between tumor and marker and the whole head (Fig. 4). Close the volume reading tool, and use the ruler tool to measure the distance among the three models (Fig. 5), rotate different angles to ensure that the three lines are on the same plane (Fig. 6). By this time, a triangle ABC can be obtained. Use model tool again, close the three-dimensional models of tumor and marker, leaving only line segments (Fig. 7). Once again, confirm that these three lines are in the same plane and each two line segments intersect at one point. Suppose that the projection point of the tumor on the 2 marker line (AB) segment is D. According to the triangle Pythagorean theorem, the lengths of AD and BD can be calculated (Fig. 8). Therefore, the precise projection point of the tumor on the body surface can be calculated. (It should be pointed out that due to the radian of the scalp, there is a certain error in measuring directly with a tape measure. It is more accurate to use a pencil compass to measure the distance between two points. However, due to the close distance between point A and point B, the length of arc AB and line AB are approximately the same. In this case, the margin of error is 0.5 mm between direct measurement with a tape measure and measurement with a pencil compass. For a tumor with a diameter of 2cm, this error can be ignored. Therefore, it is feasible to measure directly with a soft ruler).

In operating room mark the position of the tumor for operation according to the calculation results (Fig. 9). Perform the scalp incision centered on the tumor. Two burr holes were made on the sagittal sinus, carefully peel off the dura mater, maintain the integrity of the sinus, and avoid rupture and bleeding. After the the bone flap is removed, and the location of the tumor was consistent with the preoperative calculation result.

In this case the dura mater was eroded by the tumor. After cutting the dura along the lateral side of the tumor, there is still an arachnoid separation between the tumor and the cerebral cortex. The tumor was separated from the cerebral cortex to the edge of the sagittal sinus. Due to infiltration of sagittal sinus a Simpson grade II resection was achieved. After the tumor was gross total resected under the microscope, the cortical vessels were well preserved. Under the premise of the accurate location of the tumor, the dura mater can meet the needs of surgery only by limited incision.(Fig.10)

## Results

Our described techniques exactly localized the tumor that was removed with small and localized craniotomy. The patient recovered well after operation, and no complications such as bleeding and infection occurred. She was discharged from hospital 3 days after the surgery.

## Discussion

The term "parasagittal meningioma (PSM)" is applicable to tumors involving the sagittal sinus and adjacent dura and falx cerebri [1]. Cushing and Eisenhardt first described parasagittal meningioma as a meningioma attached to the sagittal sinus without brain tissue separating it from the sinus. [4] It accounts for 19.5% to 45% of intracranial meningiomas. The lateral wall of the sagittal sinus may be partially or completely invaded by a tumor in the sinus cavity. In some cases the tumor may partially or completely block the sagittal sinus. [1] Parasagittal meningioma is a challenge for neurosurgeons all over the world [3]. Especially if it invades the superior sagittal sinus cavity and the bridging veins are wrapped or adhered, it is likely to suffer severe neurological sequelae if any vascular injury during the procedure [2]. In these cases, the tumors may invade the sagittal sinus in varying degrees. According to the literature, the main treatment options of these tumors is surgical resection and radio-surgery [3]. The best surgical procedure for parasagittal meningioma is to complete resection with minimal complications [2]. The premise of safe operation is to locate the tumor accurately. The localization of intracranial tumors is a skill that every neurosurgeon must master. In the past, it was mainly determined by experience accumulation or according to some signs on the image and based on craniometrics points. Subjective factors account for a large proportion, and there is unavoidable deviation. In order to compensate for the adverse effects of errors, a large range of bone window exposure is often selected to include the lesions as much as possible. This is not compatible with the concept of precision medicine advocated now. The application of neuronavigation can solve this problem well, but because of its high costs, it has not been popularized in hospitals in underdeveloped areas.

3D slicer [www.slicer.org](http://www.slicer.org) is an open-source software developed by Harvard Medical School and Massachusetts Institute of Technology (MIT). It uses computer algorithms to process medical images. It is powerful research software and has been widely used in medical research and education. [8] Because of its open-source characteristics, many scholars have developed new editing tools and algorithms to improve their functions. For example, Dafeng Ji used it to reconstruct the cerebral fiber bundle. [5] Choueib, s, and others have used it to create different virtual medical scenes. Compared with the mouse

monitoring method, virtual reality has a strong advantage in the interactive application of the medical scenes. [6] At present, many scholars have applied its navigation function in clinical surgery [9]. It has been widely used in intracranial diseases, such as Shujing Yao et al who used the software to evaluate the responsible vessels of trigeminal neuralgia and hemifacial spasm before the operation. [10] Hou, Yuan Zheng et al. used a smartphone camera combined with 3dlicer software to realize the projection positioning of lesions. [11] This method we introduced can be used to mark the scalp directly without additional projection equipment or smartphone. It is simpler and cheaper. Therefore, this method is very practical for hospitals especially for those in developing countries and regions, and it is worth promoting.

## **Conclusion**

We have adopted this simple and effective computer aided localization method. It has been proven by clinical practice that it is cheap and accurate. It can bring great convenience for the resection of small tumors in parasagittal sinus or parafalx cerebri, which is worthy of promotion.

## **Declarations**

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### **Authors' contributions:**

Sajjad. Muhammad confirmed the scientificity of the method and guided and modified the paper. Rui Zhang applied the method and improved it to make it simple and easy to use, and wrote this manuscript.

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### **Availability of data and materials:**

The data in this paper come from image data and open source software computing. We are happy to share the methods we have established in this paper.

### **Ethics approval and consent to participate:**

The research process was reviewed and approved by the Ethical Review Committee of Xingtai People's Hospital, and the approval number is 2020/087.

### **Consent for publication:**

Written informed consent will be obtained from their legally authorized representatives. All authors agree that the article will be published. The privacy of patients will be effectively protected.

### Competing interests:

All authors certify that we declare that we have no **financial** and personal **relationships** with other people or organizations that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the position presented in, or the review of, the manuscript entitled, "Application of computer-aided image reconstruction and image guided in parasagittal Meningioma resection".

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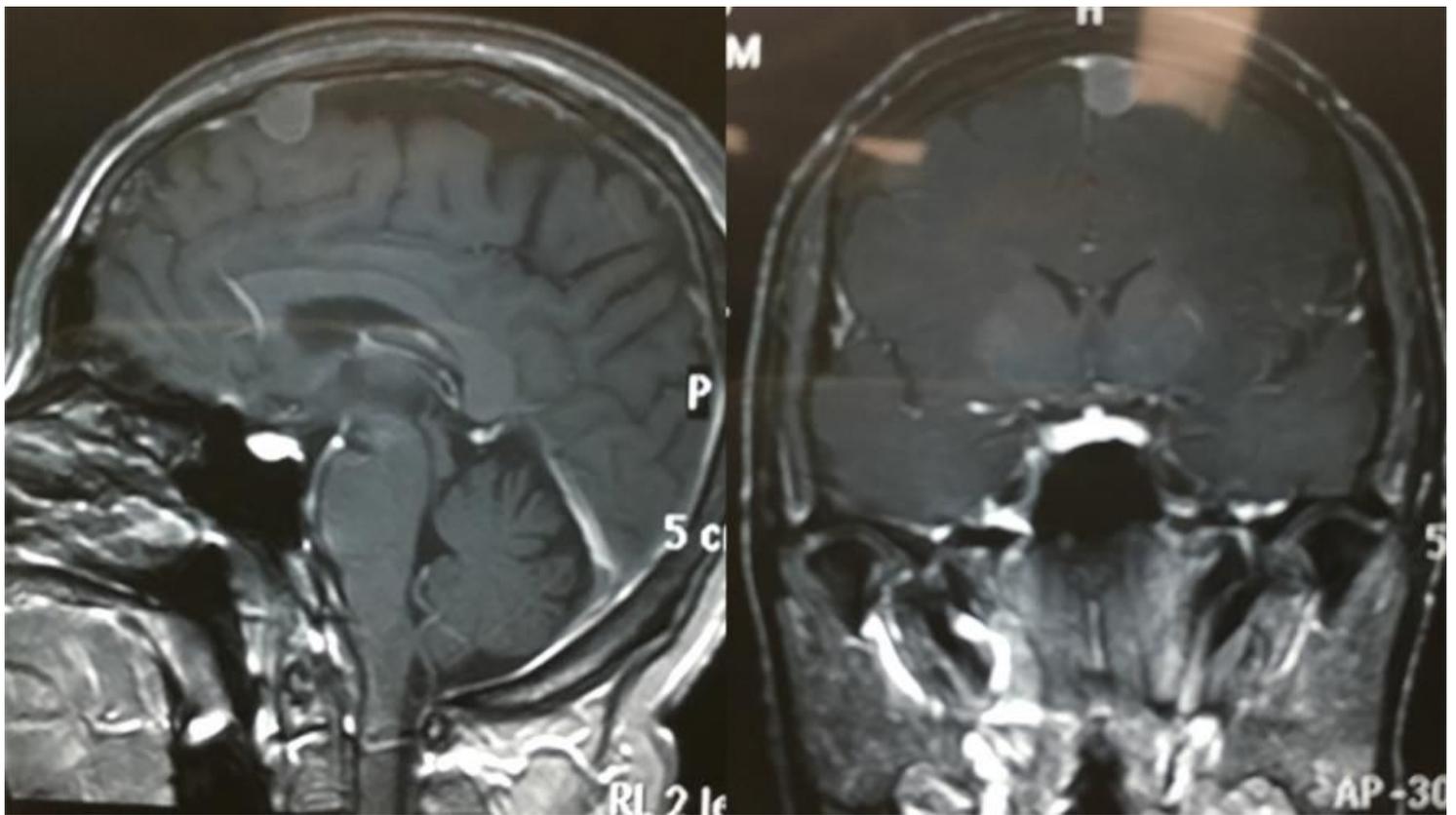
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## Figures



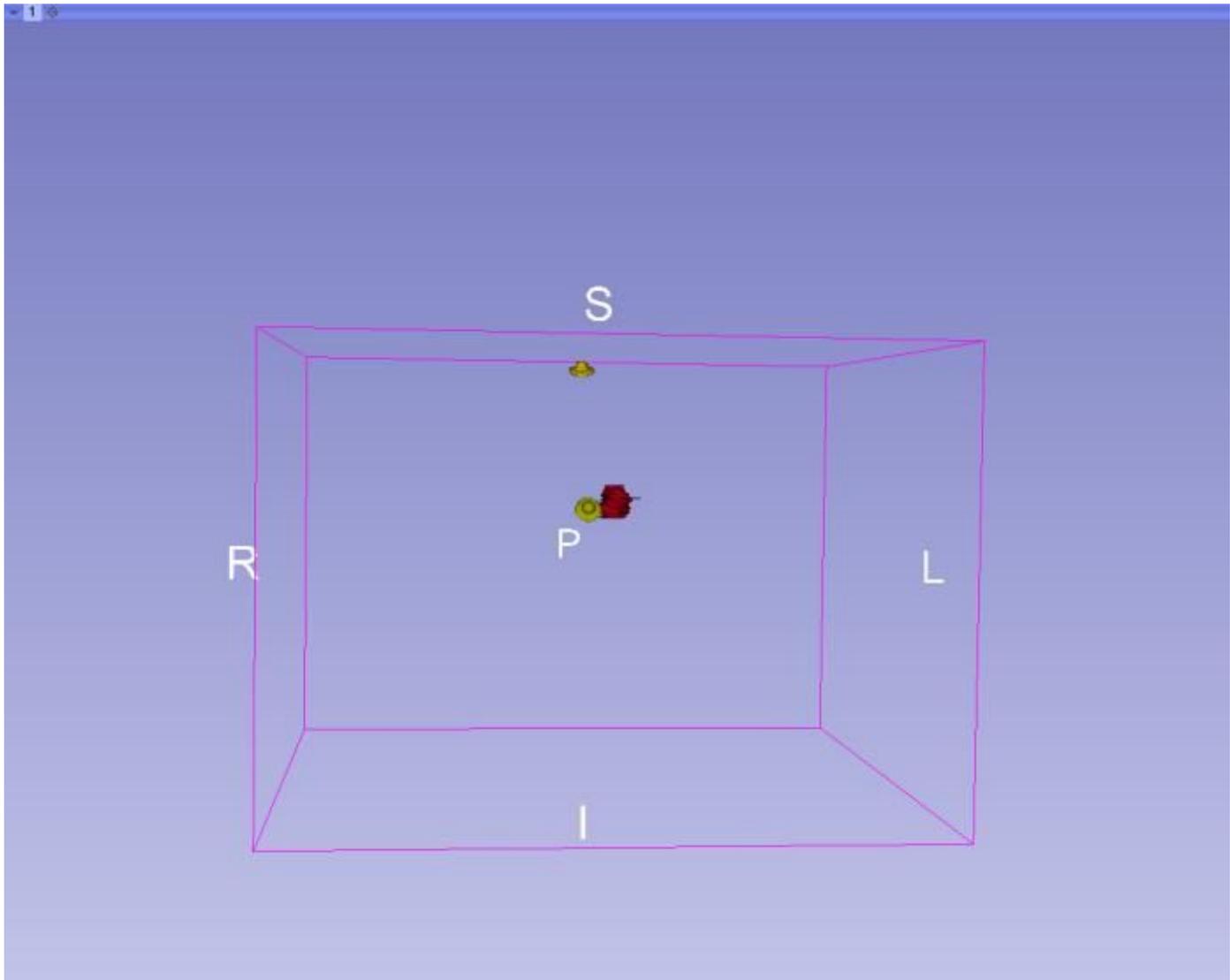
**Figure 1**

After admission, MRI showed that the tumor was located near the sagittal sinus, the tumor has invaded the sagittal sinus.



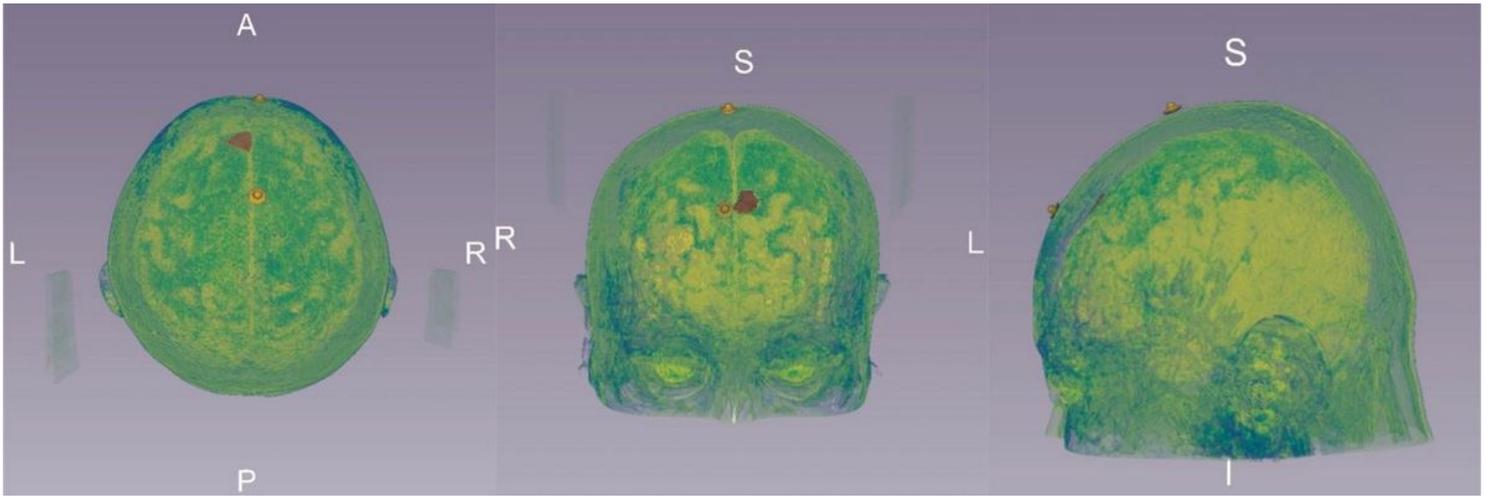
**Figure 2**

After admission, MRI showed that the tumor was located near the sagittal sinus, the tumor has invaded the sagittal sinus.



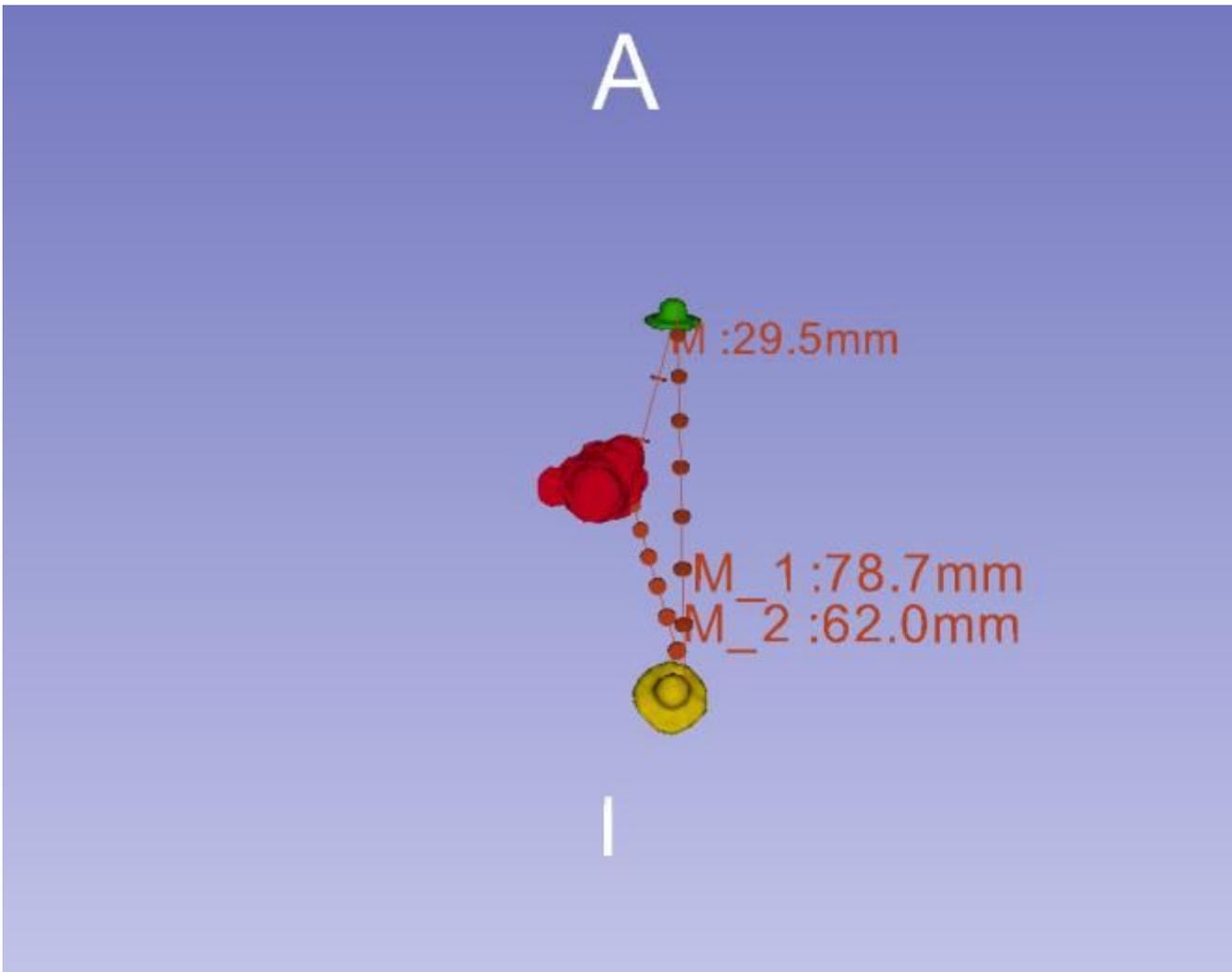
**Figure 3**

Through the reconstruction function of the software, the spatial relationship between tumor and marker can be observed.



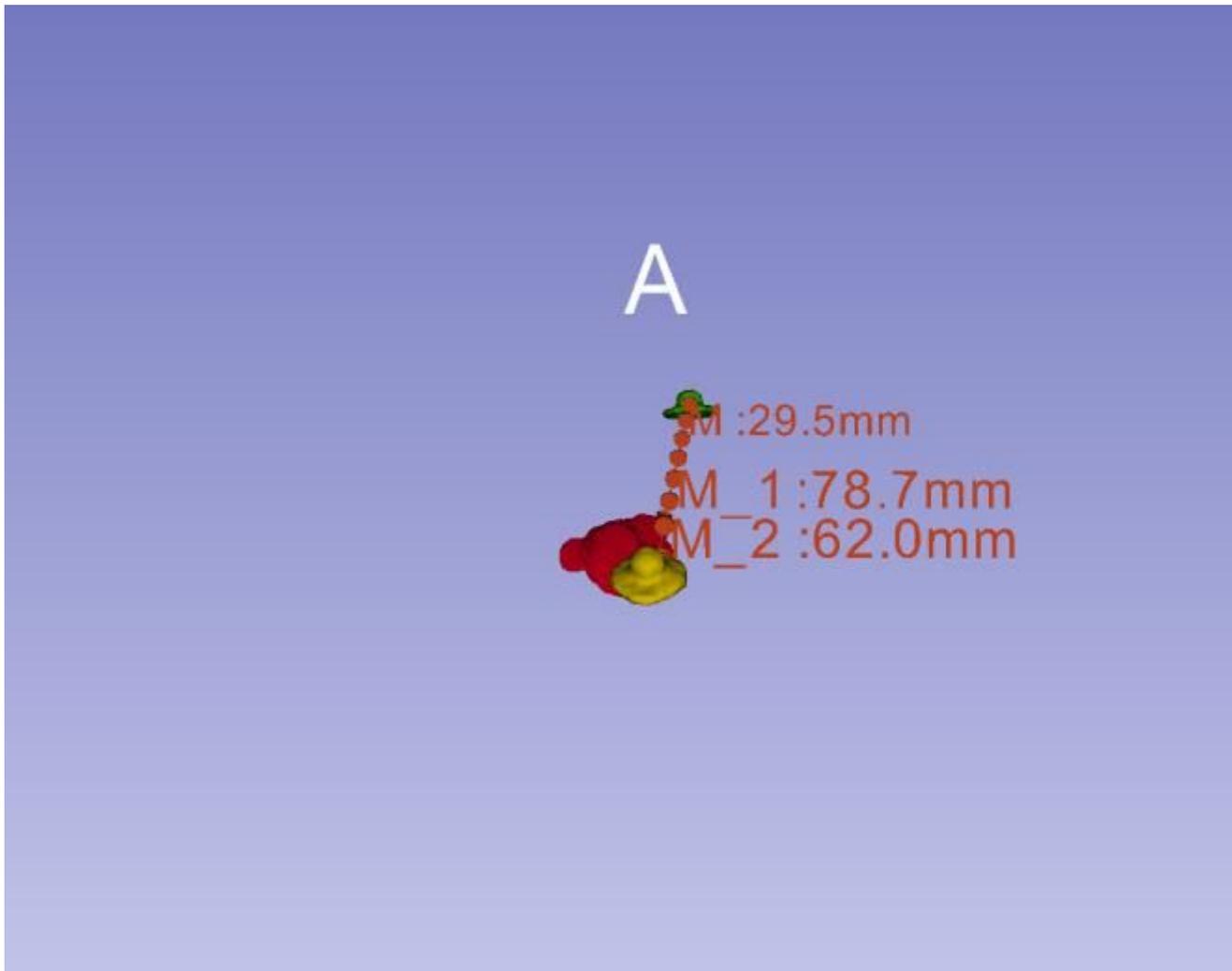
**Figure 4**

The ct-fat sequence reconstructed with the Volume Reading tool can display the tumor, marker and its surrounding anatomical structure completely.



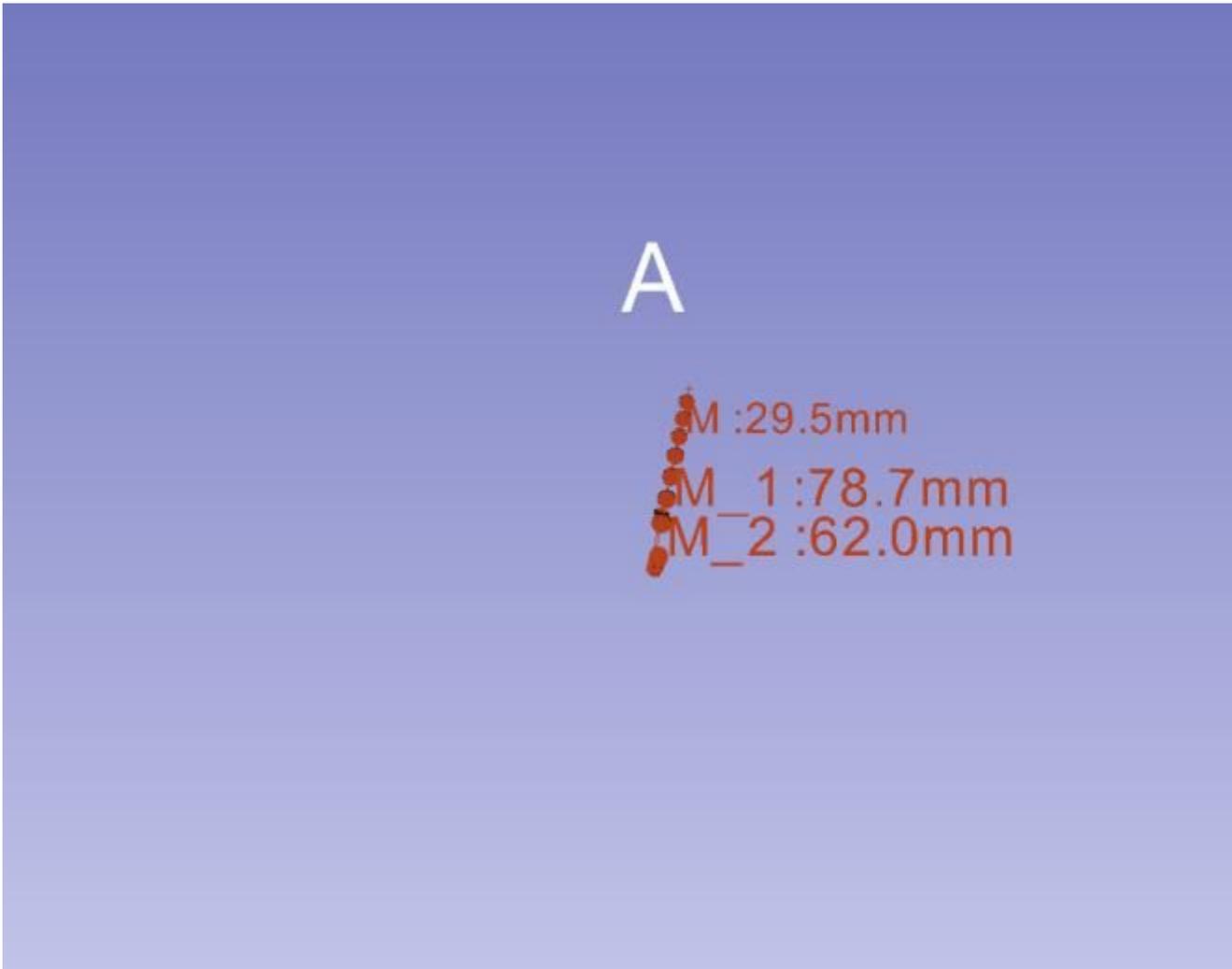
**Figure 5**

The measurement tool measures the distance between the three models.



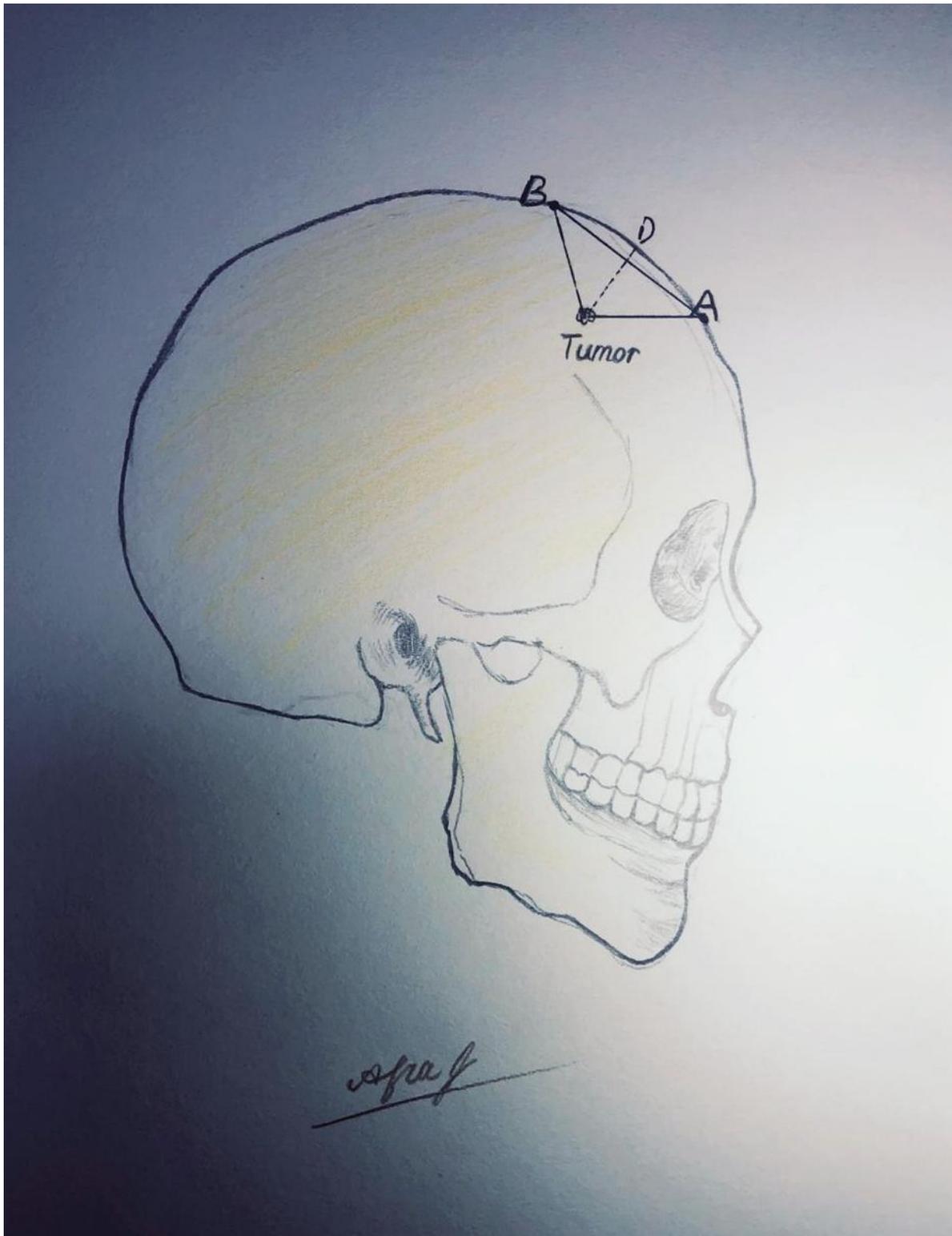
**Figure 6**

By rotating the model angle, make sure that the three line segments are in the same plane.



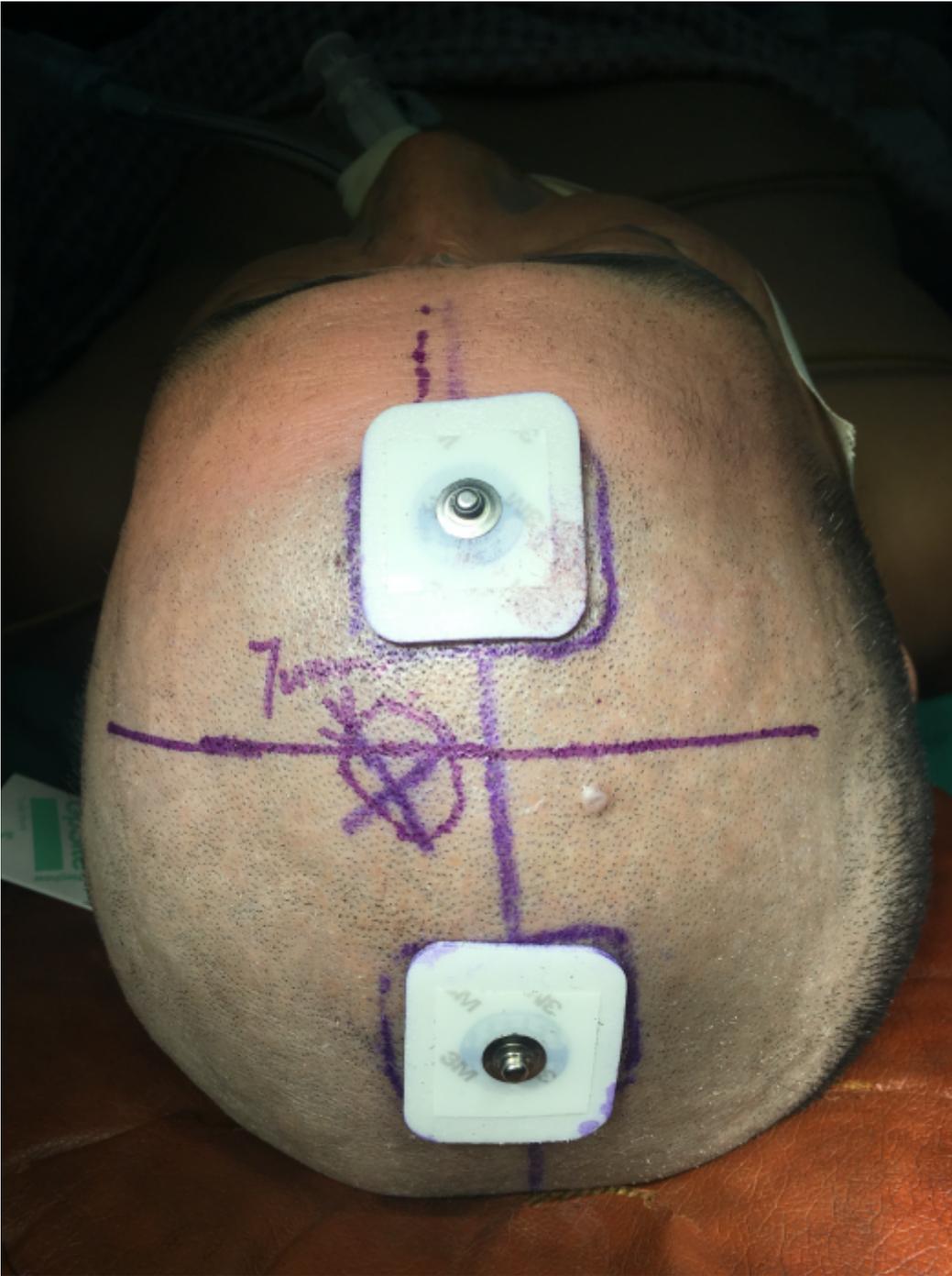
**Figure 7**

After closing the model, it is more convenient to confirm whether the three line segments are in the same plane, and each two line segments intersect at one point.



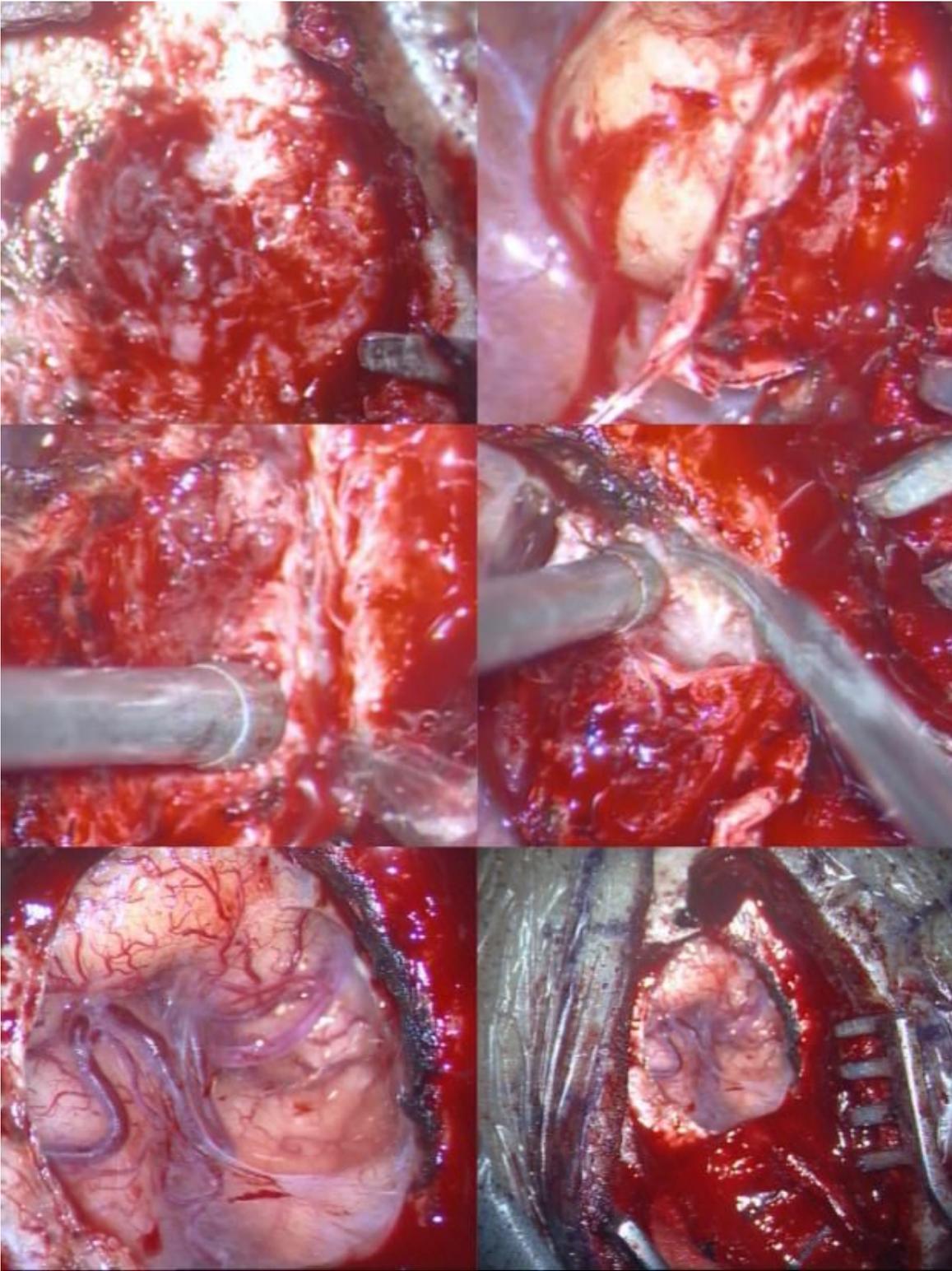
**Figure 8**

According to the measurement results and the triangle Pythagorean Theorem, the projection point D of the tumor on the scalp can be calculated. And the arc AB is approximately equal to the line segment AB.



**Figure 9**

After anesthesia, mark the projection position of the tumor on the scalp according to the calculation results.



**Figure 10**

Intraoperative images showing exact location of meningioma using computer-aided method.