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Using of three dimensional volume rendering angiography in the determination of vessel-free areas of the scalp in the patients underwent intracranial aneurysm surgery during the placement of three-pins metallic head fixation device

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ABSTRACT

Three-pins head holder device has been safely used for many years in many neurosurgical procedures for providing 3-point rigid cranial fixation. Equal impingement of pins ensures firm skull positioning and fixation after carefully positioning of skull pins around the vessel free areas. The raw data of the three-dimensional computerized tomography angiography (3D-CTA) obtained from the patients with subarachnoid hemorrhage were transferred to computer and recorded in a software program. This software program created three-dimensional images of skull using previously transferred raw data with volume rendering technique. Safe areas for pins placement, in terms of vessel-free areas, were determined using three-dimensional volume rendering angiography of the skull. The study group consists of 53 (27 female and 26 male) patients. The mean age of the patients was estimated as 57.9±9.7 years. Branches, distribution and critical anastomosis of the superficial temporal artery were also determined. In the other way, the course of the posterior auricular and occipital artery ascending along the external surface of the mastoid bone was also detected in all cases. In the patients underwent surgery for intracranial aneurysm, using of three-dimensional volume rendering angiography may be used in the determination of vessel-free areas of the external surface of the scalp during the placement of three-metallic pins of head holder device.

1. Introduction

Three-point metallic head fixation device has been safely used by neurosurgeons for many years in many neurosurgical procedures including cerebral, cervical and upper thoracic regions in the stabilization and fixation of the head (Yasargil, 1994; Lee and Lin, 2010; Kuruoglu et al., 2015a; Kuruoglu et al., 2015b; Kuruoglu et al., 2015c). It was originally invented and developed by FH Mayfield in collaboration with G Kees, a talented medical artist (Tew, 1982).

Neurological surgeon should fix the three-pins device with accurate positioning and proper pressure in order to prevent neurovascular injury during the surgical procedures. The pins of the device should be placed to the vessel-free areas in the skull. Moreover surgeons repeatedly check and confirm the immobilization of the connection parts in the avoiding of potential complications (Lee et al., 2009).

In this study, the feasibility of the using of three-dimensional volume rendering angiography in the

determination of vessel-free areas of the scalp in the patients underwent intracranial aneurysm surgery during the placement of three pins metallic head fixation device was evaluated and literature was reviewed.

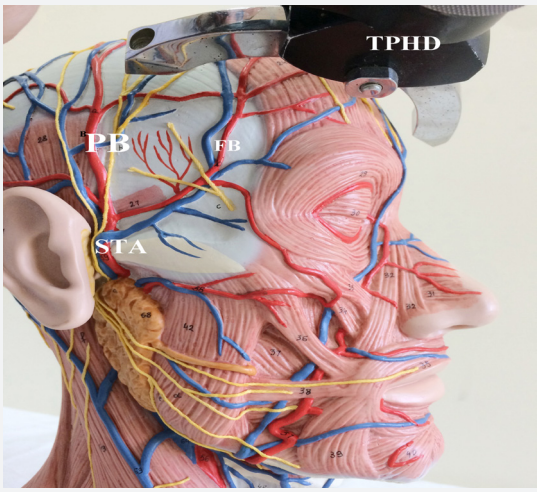

Fig. 1. This figure shows the application of three-pins head holder to the frontal area in a model before the operation (**PB:** Parietal branch; **STA:** Superficial temporal artery, **FB:** Frontal branch; **TPHD:** Three-pins head holder device)

2. Materials and methods

Any additional radiological examination providing a drug was performed to the patients for this study. The patient population included the cases that were brought to our neurosurgery department because of subarachnoid hemorrhage, and further decided to perform a 3D-CTA for cerebral aneurysm evaluation. The raw data of the 3D-CTA were transferred and recorded to a computational software database. The purpose of performing 3D-CTA was only the examination of the intracranial vascular pathology after the insult of subarachnoid hemorrhage. Some part of these raw data were used for examination of the three dimensional vascular anatomy of the scalp by using three-dimensional volume rendering angiography. Imaging data were stored in digital imaging and communications in medicine (DICOM) format and subsequent analyzed with imaging software to convert into the three-dimensional volume rendered neurovascular images.

Three-dimensional images of the head were evaluated in terms of general shape, distribution, location, critical anastomosis, and variations of the scalp vasculature in the determination of vessel-free areas for three-pins placement before the aneurysm surgery. The distance of the frontal and parietal branches of the STA, posterior auricular and occipital artery was estimated in according to medial epicanthus and the pinna. The types of the variations of the superficial temporal artery including frontal and parietal branches were also evaluated. According to measured values, vessel-free areas were marked on the model testing with three-pins head fixation device (Fig. 1, 2). The distance of the safe zone from the pinna and the medial epicanthus were estimated and marked on the patient's skull before applying of the three-pins head holder (Fig. 3, 4, 5). The distance of the safe zone from mastoid tip and pinna was estimated in the occipital region (Fig. 6).

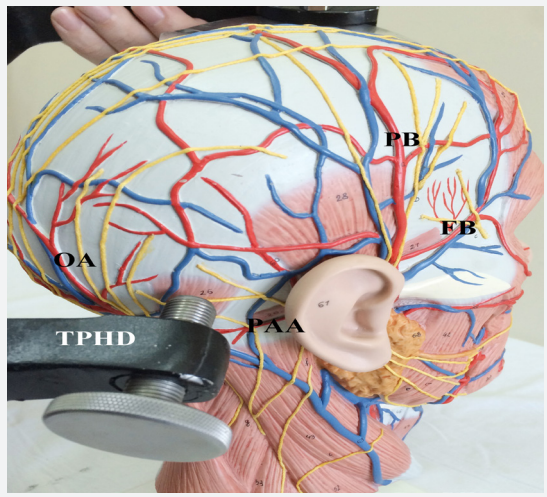

Fig. 2. This figure shows the application of three-pins head holder to the occipital area in a model before the operation (**TPHD:** Three-pins head holder device, **PAA:** Posterior auricular artery, **OA:** Occipital artery; **PB:** Parietal branch; **FB:** Frontal branch)

3. Results

The study group consisted of 53 (27 female and 26 male) patients. The mean age of the patients was estimated as 57.9±9.7 years. Any additional radiological procedure and/or drug were performed to any patient for this study. The purpose of the radiological examination of the patients was only diagnosing and examining of their own disease. The radiological images from this examination were retrospectively transferred to a computer. Three-dimensional imaging of scalp vasculature was created with 3D-Volume Rendering Technique by using OsiriX MD software program.

Normal arterial vascular anatomy was found in 28 (52.83%) of the cases. Remaining 23 (47.17%) of the cases had some variations. The common variations were found as frontal branch duplication, parietal branch duplication, and frontal and/of parietal branch re-bifurcations. Distorted vascular anatomy was found in 23 (47.17%) of the patients. The most frequent distortion was the fusiform dilatation of STA in the cases with intracranial aneurysm.

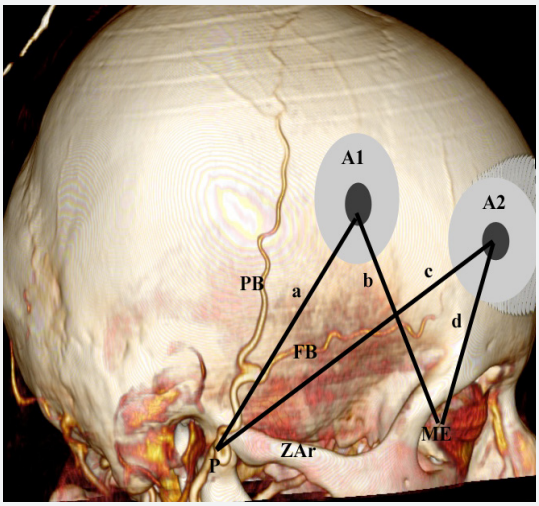

Fig. 3. This figure shows the safe areas in a patient with normal vascular anatomy (**A1:** Safe area on the parietal area; **A2:** Safe zone on the frontal area; **PB:** Parietal branch; **FB:** Frontal branch; **P:** Pinna; **ZAr:** Zygomatic arch; ME: Medial epicanthus; **a:** The distance from pinna to parietal safe zone; **b:** The distance from medial epicanthus to parietal safe zone; **c:** The distance from pinna to frontal safe zone; **d:** The distance from medial epicanthus to frontal safe zone)

4. Discussion

Mayfield-Kees three-point head fixation device has been used successfully and safely in neurosurgical operating theatre for many years. It is simple to use and offer safe fixation of the head during surgery (Yasargil, 1994). Slipping of the device pins, infection, air embolism, penetration through the cranium, and epidural hematoma puncturing major scalp vessels, were reported in seldom cases (Yasargil, 1994; Lee et al., 2009; Lee and Lin, 2010). It consists of a basic unit, swivel adapter, and the three-point head holder. The pins should always be positioned on the cranium in areas not covered by muscle.

Regardless whether neurosurgeon uses the Mayfield, Gardner, Sugita, or any variations, several methods should be taken into account in the avoiding or reducing the complications related with the pins (Yasargil, 1994). Using sterile technique, cleaning of the area with shampoo before procedure, application of large amount of betadine, adjuvant antibiotic treatment, using sterile pins will reduce the infection rates. The tension of the pins should be checked by hand, and should insert at approximately 90 degrees to the scalp in order to avoiding slippage. If the patient is positioned in supine, the single prong should be placed just above the mastoid, and double arm should be positioned at the temporalis insertion line. For the avoiding of large scalp vessel puncturing, in the patients underwent aneurysm surgery, the images obtained from three-dimensional volume rendering angiography may be used to detect the vessels.

The volume rendering technique may be used in the three-dimensional evaluation of some anatomical structures such as the superficial temporal and artery, arterial branching and vascular variations, the extension of the temporal muscle, and the thickness of the skull. Volume rendering technique is a group of modalities in the converting of two-dimensional images to the three-dimensional images (Drebin et al., 1988; Calboun et al., 1999; Tomandi et al., 2006). The two-dimensional images acquired by a computerized tomography and magnetic resonance imaging are used to create the volume rendered images (Drebin et al., 1988; Calboun et al., 1999; Hwang et al., 2011). In this study, we used OsiriX software program for volume rendering technique to create three-dimensional images of the feeder arteries of the scalp.

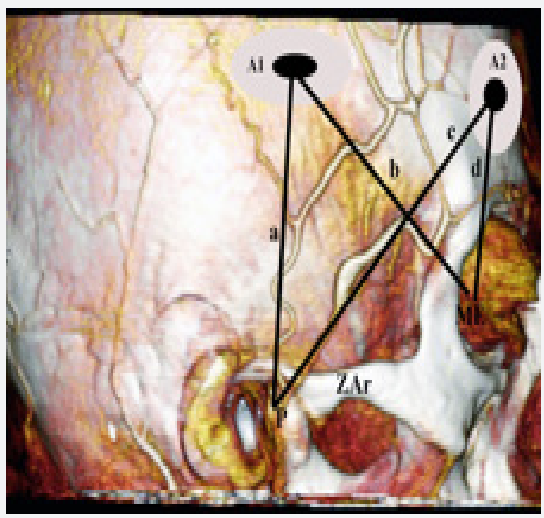

Fig. 4. This figure shows the safe zones in a patient with the variations of the scalp vasculature (**A1:** Safe area on the parietal area; **A2:** Safe zone on the frontal area; **PB:** Parietal branch, FB: Frontal branch; **P:** Pinna; **ZAr:** Zygomatic arch; **ME:** Medial epicanthus; **a:** The distance from pinna to parietal safe zone; **b:** The distance from medial epicanthus to parietal safe zone; **c:** The distance from pinna to frontal safe zone; **d:** The distance from medial epicanthus to frontal safe zone)

Three-dimensional viewer provides modern rendering modes such as multiplanar reconstruction, surface rendering, volume rendering, and maximum intensity projection. In the present study, we used OsiriX software in the processing of DICOM images. This software may show the basal cerebral arteries and skin feeders together with the bone muscle structures

of the head. Using of this technique in the cases with aneurysmal subarachnoid hemorrhage can give useful knowledge about the shape, distributions, branching, diameter and location of the extra-cranial skull arteries. Location of the arteries can be used in the determination of the pins places for the preservation of the arteries. Preserving of the arteries may prevent the occurrence of the complications related with the arterial origin.

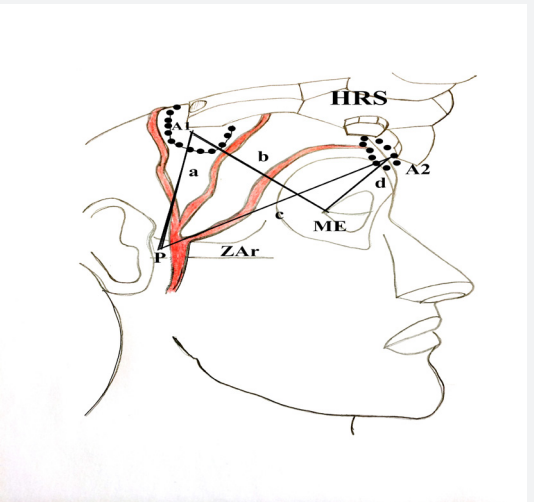

Fig. 5. This schematic figure shows the application of head resting device to the safe zone after measuring of the safe zones from the pinna and medial epicanthus (**A1:** Safe area on the parietal area; **A2:** Safe zone on the frontal area; **PB:** Parietal branch, **FB:** Frontal branch; **P:** Pinna; **ZAr:** Zygomatic arch; **ME:** Medial epicanthus; **a:** The distance from pinna to parietal safe zone; **b:** The distance from medial epicanthus to parietal safe zone; **c:** The distance from pinna to frontal safe zone; **d:** the distance from medial epicanthus to frontal safe zone; **HRS:** Head resting device).

In the present study, it was found that 47.17% of the cases showed some type of variations. Duplication of frontal and parietal branch of superficial artery may be seen in the frontal and parietal region in where double arm of the head-resting device is applied. On the other hand, fusiform dilatation of the vessels may

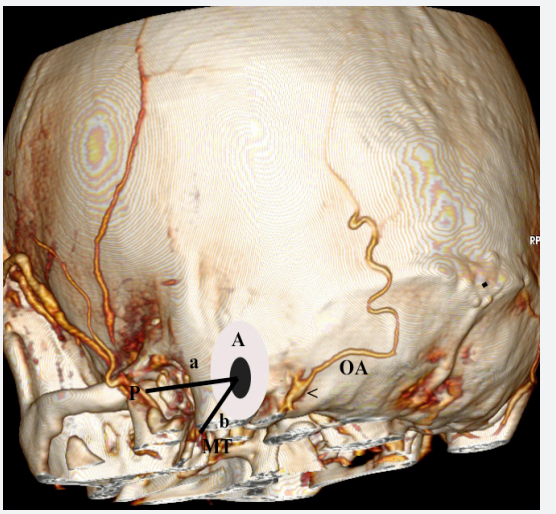

Fig. 6. This figure shows the safe zone on the mastoid part of the temporal bone, and measuring of the distance from the mastoid tip and the pinna (**A:** Occipital safe zone; **P:** Pinna; **a:** The distance from the pinna to the occipital safe zone; **b:** The distance from the mastoid tip to the occipital safe zone; **OA:** Occipital artery; arrow shows the enlargement of the occipital artery)

be present. In order to reduce vessel puncturing and possible venous air embolism the tips of the pins should be positioned on the relatively avascular regions. Using of this technique vascular anatomy of the scalp may be determined in terms of pins placement.

In conclusion, superficial temporal and occipital artery and their branches may be imagined with three-dimensional volume rendering technique intended for imagination of basal cerebral arteries. These images may be used in the determination of the localization of the pins of Mayfield-Kees head holder. The position and branching of the arterial vessels feeding to the scalp, and extension of the temporal muscle in relation with the external auditory meatus and epicanthus may be estimated using this software program and marked on the skin surface. The using of 3D-CTA in the cases with aneurysm is useful in the determination of pins places in the head to avoid the vessel injury related to pins.

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