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Establishing the Precise Location of Apanga Marma and defining its Structural Component through Cadaveric Study

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ABSTRACT

Background: Apanga marma is a Jatrurdhwagata marma that is positioned within half angula dimension below the tail end of the eyebrow and outer to the lateral canthus of the eye. Its injury causes andhya and dristiupaghata. Sushruta classifies it as Sira structurally, however Vagbhata classifies it as Snayu marma. The precise position, radiance, and conflicts in opinion in identifying the structural entity and applied importance of this marma must be clarified. The objective of this study was to locate and ascertain the position and structural entity of Apanga marma.

Materials and Methods: Study was conducted in two steps: Conceptual study by reviewing the literatures and cadaveric observational study by dissection over 4 cadavers.

Results and Discussion: The Apanga marma was discovered to be positioned on the anterior section of the superior temporal fossa, near the lateral canthus of the eye. Extracranial, intracranial, and intraorbital neurovascular structures were observed within the designated area. Structures in the area include the Middle cerebral artery, the Middle meningeal artery, and the Abducent nerve, which can cause visual problems or total blindness if injured.

Conclusion: Apanga marma was found to be located in the anterior section of the superficial temporal fossa, lateral to the lateral orbital edge, beneath the tail end of the eyebrow, and above the zygomatic arch. The middle meningeal and middle cerebral arteries were discovered as a specific anatomical entity in the marma area, resulting in blindness or vision impairment upon injury.

Keywords: Ayurveda, Apanga marma, Andhya dristi upaghata, Middle cerebral artery, Temporal region

INTRODUCTION

The principle of *marma* is one of several scientific notions in *Ayurveda* that require close examination to determine its utility in the field of medical science. *Marma* knowledge was practically applied in ancient warfare and wild animal hunting, by hitting the enemy or the animal while aiming the arrows at the *Marma*.¹ In the battlefield, major traumatic injuries were common. Such susceptible areas of the body were known as *Marma* in ancient times. The term *Prana* refers to vital energy. Although this vital energy is present throughout the body, it is stated that its roots are embedded at the point of union of five basic structures, namely *Mamsa*, *Sira*, *Snayu*, *Asthi*, and *Sandhi*, and these sites are called *marma sthana*.² This science of *marma*, in terms of practical application, had long since vanished, as had many other disciplines of *ayurvedic* literature. Knowledge of *marma* is critical for avoiding complications throughout *agni karma*, *kshara karma*, and *shastra karma* procedures.³ It is useful in understanding the possible anatomical structures impacted and the abnormalities that may result from trauma.

Apanga marma is a *Urdhwajatrugata* and *Vaikalyakara marma*. It is two in number and half angula in dimension. Sushruta identified Sira, whilst *Vagbhata* identified *Snayu* as the primary structural components of this *marma*. This controversies about identifying the structural entity of *Apanga marma* must be resolved. It is situated beneath the tail end of the eyebrow, outside of the lateral corner of the eye. Because the area specified in the classics is vague, it is necessary to fully understand the term in order to determine the precise location and its variance being *ardhangula*. According to *Sushruta*, *viddha lakshana* (traumatic effect) of *Apanga marma* is *Andhyatwa* (blindness) and *Dristi upaghata* (visual impairment), however *Vagbhata* just mentions *Andhyatwa*.^{4,5} So, there is need to identify the specific structure in the *Apanga marma* region that is producing visual impairment or blindness upon injury. As the *marma* is made up of multiple structures, the possible structures must be investigated through dissection in the designated *marma* area in conjunction with literature. The objective of the study was to locate and ascertain position and structural entity of *Apanga marma*.

MATERIALS AND METHODS

Source of data: Study was conducted in two steps- Conceptual study and cadaveric study

Method of collection of data: Conceptual Study- Relevant text books of *Ayurveda* and contemporary science, published research works, articles, available digital data etc. related to area of interest were reviewed and necessary informations were collected, documented and analyzed in systematic manner. **Cadaveric Dissection-** Cadaveric study was carried out over four cadavers at Department of Rachana Sharira, Sri Dharmasthala Manjunatheshwara College of Ayurveda and Hospital, Hassan, India.

Dissection was approached through temporal region in the lateral part of orbits and through roof of orbits by cutting the calvaria open and removing the brain. Dissection was done in three steps:

Locating and marking of the area of *Apanga marma* as per description in classics: The location of *Apanga marma* has been extensively discussed. This *marma* is said to be located beneath the tail end of the eyebrows, outer of the eye. The lateral end of the brow or *bhru puchchha* is located at the superolateral aspect of the lateral canthus of the eye. Because the brows were removed during cadaver preservation, the lateral end of each brow was taken into consideration using the standard technique described by Westmore. According to the Westmore's method of eyebrow aesthetics, the lateral end of the eyebrow should lie in a tangential line linking the lateral canthus and the lateral ala of the nose, and the medial end should lie in the vertical line connecting lateral ala and medial canthus. The medial and lateral sides of the eyebrow should fall in the same horizontal plane (see fig.2&3). So, the tail of brow was recognised as the intersection point of the line connecting the lateral canthus and the lateral ala of the nose with

the horizontal line drawn across the lower limit of the medial ends (head) of the two brows. A horizontal line was drawn through the lateral canthi and parallel to the upper horizontal line. On this line, a point was marked just below the tail end of the eye brow. This point which lies below the tail end of eyebrow and outer to the eye is the *Apanga marma* point.

Nailing the point and marking ardhangula pramana- A pin was nailed to secure the indicated *marma* point. Because it isn't specifically stated in the traditional literature that the *marma*'s dimensions are in terms of length, breadth, or depth, the 1/2 *angula* dimension was used as both circumference and depth. A circular area with a radius of 0.5cm (diameter 1cm) was marked and painted around the *marma* point. A point in a pin measuring 1cm from the tip was marked to explore the depth of the *marma* point.

Layer by layer dissection of structures following standard method- The 1cm area is cut opened methodologically from superficial to deep, with the help of scalpel, forceps to see the structures under *Apanga marma* area. Photographs of dissected parts were taken and structures observed were documented for analysis.

Assessment Criteria: Observation of published data, articles related to surface and regional anatomy of *Apanga marma* in identifying the structural component were done. For analyzing the structural entity of *Apanga marma*, causing visual impairment and blindness on injury to the mentioned dimension of area, layer by layer dissection was done in temporal region and orbit. Dissection proforma was prepared and utilized for documentation. Ethical approval was taken before commencement of study from Institutional Ethics Committee of Sri Dharmasthala Manjunatheshwara College of Ayurveda, Hassan, Karnataka, India. Study Design was Cadaveric observational study. Ethical clearance number is SDM/IEC/15/2018-19.

RESULTS

Dissection approaching from temporal region: After locating the site of *Apanga marma*, dissection was carried out over 4 cadavers in specified region by following the standard methods described in Cunningham's Manual of Practical Anatomy. After removing the skin, the structures observed were:

1. Superficial fascia- Fibro-fatty tissue containing branches and tributaries of superior temporal vessels.
2. Epicranial Aponeurosis- A thin sheet of epicranial aponeurosis of scalp was seen deep to the superficial fascia.
3. Temporal Fascia- Between 2 layers of temporal fascia, structures seen are Zygomatico-orbital artery which was found to be running forward along the upper border of the zygomatic arch and was passing in the *marma* region and ended at the lateral angle of the orbit and the Zygomatico-temporal nerve that was passing superior to the Zygomatico-temporal artery (vide Fig. 4).

4. Temporalis Muscle- Temporalis muscle was observed deep to the temporal fascia.
5. Orbicularis oculi
6. Pericranium was loosely attached to the floor of the temporal fossa.
7. Floor of Temporal Fossa- An area with half *angula* (1cm diameter) on the floor of this fossa was marked with paint under the marked area for *Apanga marma*. The marked area included part of temporal, zygomatic and part of sphenoid bones (vide Fig. 5&6).

The circular marked area of bony wall was cut and all the fragments were removed. It was observed that *ardhangula pramana* area marked for *Apanga marma* point included 1/3rd part medially related to lateral wall of bony orbit and related structures of orbit. The rest 2/3rd of the marked area, when bony fragments were removed the structures related to the brain (endocranial) and associated features were seen and the nailing point was falling exactly at Sylvian point (vide Fig.7). Structures seen deep to the bony wall were-

Endocranial components:

1. Dura matter: Thick fibrous sheet of dura matter was seen. Part of Middle meningeal artery ascending upward and backward, was observed. A part of sphenoid bone forming the lateral orbital wall, was intervening in between the eyeball and dura matter. (vide Fig.7&8)
2. Arachnoid matter
 - 1.1. Blood vessels: i) The middle meningeal artery was seen running upward and backward in between dura matter and inner surface of bony temporal fossa (vide Fig. 7). ii) The middle cerebral artery was observed passing through Sylvian point and running posteriorly along the posterior ramus of lateral sulcus (vide Fig. 8&9). Many cortical branches from the artery were passing upward and downward along the sulci, supplying the superolateral surface of frontal and temporal lobes. The cortical branches were followed and it was observed that they were supplying the supero-lateral surface of cerebrum including frontal eye field area and also to the up to the vicinity of area 17, 18 and 19 (vide Fig. 10).
3. Brain: Parts of frontal and temporal lobes of cerebrum separated by lateral sulcus
4. Optic nerve in much depth (vide Fig. 11).

Orbital components:

1. Periorbital fascia
2. Lateral rectus muscle-
3. Inferolateral part of lacrimal gland-

4. Lacrimal vessels-
5. Lacrimal nerve-
6. Abducent nerve
7. Communicating lacrimal branch of zygomatic nerve
8. A part of eyeball

Dissection of orbit approaching through the anterior cranial fossa: Dissection of the orbit was carried out by approaching from the floor of the anterior cranial fossa. Structures observed in the lateral aspect of orbit approaching through anterior cranial fossa in the *marma* area were (vide Fig.12):

1. Bony components: Orbital plate of frontal bone and lesser wing of sphenoid bone forming the lateral part of roof of orbit.
2. Dura matter covering the orbital roof from superior aspect
3. Orbital Fascia
4. Lacrimal nerve
5. Lacrimal artery
6. Orbital branch of middle meningeal artery
7. Lacrimal gland
8. Inferior oblique muscle
9. Abducent nerve
10. A communicating lacrimal branch of zygomaticotemporal nerve.
11. Fat
12. Fascial Sheath with Eyeball

DISCUSSION

As per the available references from the Samhita, the *Apanga marma* is said to be positioned below the tail end of *Bhru* and outer to the *Akshi*.^{5,6} *Bhru* is the sanskrit term for eyebrows, which are placed above the eye, between the forehead and upper eyelid on the lower border of the brow ridge, and *puchchha* is a hairy tail or end of anything.^{7,8} According to the Samhita, it is located in the anterior region of the superior temporal fossa, below the lateral end of the brow and exterior to the lateral canthus of the eye. The brow is divided into three sections: head, the medial most part, body, the middle arching part, and the tail, which is the lateral most tapering part. Various studies have demonstrated that the length of the tail of brow varies by person, sex, ethnicity, race, and so on.⁹

As per Westmore's model of eyebrow aesthetics, a point at the superolateral part of the lateral angle of the eye where a tangential line drawn along the lateral edge of nasal ala and lateral canthus of the eye meets with a horizontal line drawn along the lower limit of head parts of both eyebrows can be taken as the landmark of

lower limit of tail of eyebrow.⁹ As a result, the *Apanga marma* can be precisely located on the imaginary horizontal line formed along the lateral angles of the two eyes at the place below the lower limit of the tail of the brow and outer to the lateral angle of the eye.

During the layer-by-layer dissection in the designated area, it was discovered that the Zygomatico-orbital arteries and Zygomatico-temporal nerve were passing beneath the extracranial component of the *marma* area. After removing the extracranial soft tissue component, including the temporalis, it was found that the *marma* was coinciding with the area on the floor of the anterior portion of the superficial temporal fossa, just lateral to the fronto-zygomatic junction and above the zygomatic arch. The area is confined inferiorly by the zygomatic arch and anteriorly by the lateral orbital rim and includes a portion of the temporal, sphenoid, and zygomatic bones. This is the actual location of *Apanga marma*.

Various authors have attempted to correlate composition of *Apanga marma* with structures on the lateral side of the eyeball, while keeping traumatic effect as a criterion in consideration. Ghanekar has stated that *Apanga marma* is made up of zygomatico-temporal vessels that run near the outer corner or canthus of the eye.⁴ However these structures appear to have no clinical importance in relation to visual function, hence they are excluded as the main structural elements of *Apanga marma*. The regional anatomy indicates that there are no extracranial *sira* or *snayu* within the *Apanga marma* area that could cause blindness or vision impairment if harmed. These structures should be present deep to the cranial bony wall.

Exploring in the deeper by removing the bony wall of the *marma* area, part of the middle cranial cavity with the Middle meningeal artery and Middle cerebral artery were encountered in the lateral 2/3rd part while part of the orbital cavity with Lacrimal artery, Lacrimal nerve and Abducent nerve were seen in the medial one by third of the *Apanga marma* area.

The dimension of *marma* has been referenced in *Ayurvedic* books in terms of *Swa-angula*, but details, such as length, breadth, or depth, are unknown. The dimension of the *marma*, when measured in terms of circumference and depth, appears to be more relevant. According to investigations conducted by several scholars, 1 *angula* *pramana* of *marma* is around 2cm.¹⁰ As a result, 1/2 *angula* dimension of *Apanga marma* equals 1cm. The structures that were seen in the *Apanga marma* within 1cm of circumference (radius=0.5cm) and depth were Zygomatico-orbital artery, Zygomatico-orbital vein, and Zygomatico-temporal nerve in the extracranial region of temporal fossa. By nailing 1cm deep in the *Apanga marma* site, the point of the nail was found to reach the floor of the superior temporal fossa. The indicated circular area of 1cm diameter on the temporal fossa consists of the lateral 2/3rd forming the cranial fossa wall and the medial 1/3 constituting the lateral orbital wall. Middle meningeal artery and Middle cerebral artery with cortical branches in Sylvian point were observed deep to the bony wall of temporal fossa exactly inside the 1cm circumference. The orbital fascia, lateral rectus muscle, lacrimal

vessels, lacrimal nerve, abducent nerve, communicating lacrimal branch of Zygomatico-temporal nerve, and a small portion of the inferolateral portion of the Lacrimal gland were observed on the anterior part within a 1cm circumference deep to the lateral orbital wall.

Ideology behind fixing the *pramana*(extent) of *Apanga marma* is related with deep seated structure involving in blindness and visual impairment on injury. However, the effect related to the visual function following the trauma on the lateral aspect of the eye may depend on the type, severity, impact of trauma, direction of the impact and structural entity involved. The trauma with less intensity affects only the soft tissue component present in the *marma* region while high intensity trauma may cause the fracture injury of lateral wall of middle cranial fossa and lateral wall of orbital cavity causing damage to the underlying structures and thence affecting visual function and other related problems.¹¹

According to Mishra JN, a slap, blunt damage, or piercing injury to the lateral side of the face right behind the superolateral angle of the orbital edge might cause lacrimal artery rupture and haematoma. The vascular bleeding at this location may cause pressure, causing in partial or total vision loss. Lacrimal gland degeneration can be caused by an obstruction in the vascular supply to the lacrimal gland or a haematoma affecting the lacrimal nerve. An obstruction of the vascular supply to the lacrimal gland or a haematoma affecting the lacrimal nerve can cause lacrimal gland degeneration.¹²

As per opinion of *Pathak* and *Patil*, the structures connected to this *marma* are the optic nerve, ophthalmic nerve and its ciliary branches, lacrimal, and abducent nerves. Vision loss or impaired vision results from injury to various structures and arteries in this region.^{13,14}

The middle meningeal artery has no direct relationship with the visual organs; however, this artery is the most common source of extradural haematoma, which compresses the motor portion of the cerebrum and the Middle cerebral artery at Sylvian point and may result in contralateral loss of motor function. Increased intracranial pressure caused by extradural haematoma interferes with venous drainage of the eyeball, causing papilloedema, and may progress to optic nerve atrophy, resulting in blindness.¹⁵

The major artery supplying the occipital lobe, where primary visual area locates, is Posterior cerebral artery. The junctional zone near the occipital pole between the territories of middle and Posterior cerebral arteries corresponds to the striate visual cortex concerned with the macula. The phenomenon known clinically as sparing of macula is due to the collateral circulation of blood from branches of Middle cerebral artery into those of the posterior, when the latter vessel is blocked. The Middle cerebral artery may itself supply the macular area.¹⁶ Most of the parts of optic pathway of the cerebrum is fed by the Middle cerebral artery. The posterior communicating artery and branches of the middle cerebral artery supply blood to the optic tracts. The posterior and

middle cerebral arteries provide the majority of the blood flow to the optic radiations. The Middle cerebral artery may supply the posterior aspect of the calcarine sulcus with an anastomosis between posterior and middle cerebral arteries, causing the macula to be spared in cases of posterior cerebral blockage. So, blockage of the blood supply from the Middle cerebral artery due to trauma or stroke leads to disturbances in visual functions besides other neurological symptoms. In a study of 915 stroke patients, Fiona J Rowe et al. discovered that 8.1% of strokes were caused by a rupture of the middle cerebral artery. There were 28 cases of homonymous hemianopia, 6 cases of homonymous quadrantanopia, and 2 cases of restricted loss among them.¹⁷

The most common site for lateral orbital wall fractures is articulation between the zygomatic bone and the greater wing of the sphenoid, which is usually followed by disruption of zygomatic bone articulation with the frontal, temporal, and maxillary bones.¹⁸ Intracranial damage and vision loss are uncommon with isolated mild lateral orbital wall fractures. The risk of life-threatening cerebral injuries, injury to the orbital part of the cranial nerves, including the optic nerve, and globe rupture increases with the severity and posterior medial displacement of lateral orbital wall fracture. Loss of vision is a rare complication of facial fracture, with a reported frequency of 3 percent.¹⁹ Injury to the abducent nerve or/and the lateral rectus muscle leads in loss of eye abduction and vision impairment. Both of these structures are located in the *Apanga marma* area. Following trauma, displaced portion of the orbital wall might impinge on the extra ocular muscles, creating mechanical restriction in ocular mobility. Diplopia develops in such patients due to ocular restrictions on mobility and is suggestive of rectus muscle or perimuscular tissue entrapment.²⁰ Antoniadis et al. reported 3 cases of RTA having blowing injury on lateral facial region producing Abducent nerve dysfunction with visual disturbances. Visual disturbances were significantly improved after surgical reduction of fractures releasing the nerve free.²¹ A case of a blow-in fracture of the left lateral orbital wall with two medially displaced broken fragments impinging on the lateral rectus and globe without retrobulbar haemorrhage or cerebral injury was reported by Raje VV and Nilesh K. The patient initially had decreased visual acuity and limited extraocular movement with lateral gaze, but after having the impinging bone pieces surgically removed, he fully recovered with normal vision and ocular motions.²²

High intensity trauma in this area may disrupt optic canal leading to Traumatic Optic Neuropathy (TON). A case reported by Irawati et al. with trauma on the lateral orbital rim causing TON and resulting in various forms of visual dysfunction including altered visual acuity, diplopia, etc. The patient acquired almost normal visual acuity two months after surgical reconstruction of orbital rims and correction of soft tissue entrapment.²³

CONCLUSION

Conceptual and cadaveric observational study has favoured to locate and ascertain the position and structural entity of *Apanga marma*. The location of *Apanga marma* was found in the anterior part of superficial temporal fossa, lateral to the lateral orbital margin, below the tail end of eyebrow and above the zygomatic arch. It is anatomically related with floor of superior temporal fossa formed by temporal and sphenoid bones and deeply related to part of middle cranial cavity forming lateral two-third portion of *marma* and lateral part of orbital cavity constituting medial one-third portion. This was substantiated from dissection by exploring the soft tissue component predominantly the neurovascular structure and its influence over producing *viddha lakshana* of *Apanga marma*. The *ardhangula pramana* of *Apanga marma* is related with the surface marking and depth. This was confirmed by nailing in the centre of *ardhangula pramana* area (circular area of 0.5cm radius) in the same location as mentioned in classics. The vascular structures (*Sira*) discovered were Middle meningeal and Middle cerebral arteries as described by *Sushruta* while neuronal structures (*Snayu*) were Abducent and Lacrimal nerves as described by *Vagbhata*. *Susruta's* viewpoint appears to be more in line with the regional and clinical anatomy of *Apanga marma* as the bony wall related to cranial cavity is much thinner when compared to one by third part of *marma* area related to lateral wall of bony orbit. This is a point to be noted that the impact of injury over lateral sulcus of cerebrum and the related structures are in tune with *dristi upaghata* and *andhyatwa* as Middle meningeal and Middle cerebral arteries are found to be injured causing further damage to nervous component in the form of brain tissue.

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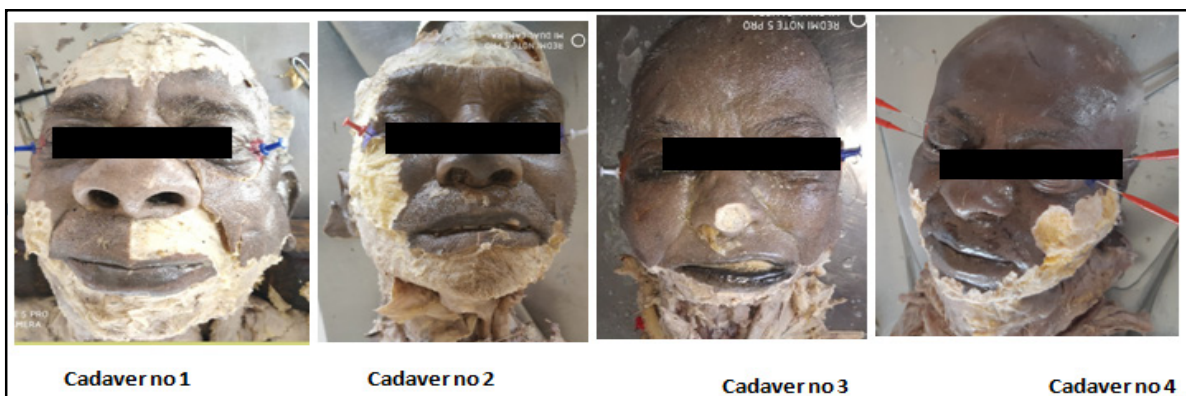


Fig 1: Cadavers used for dissection

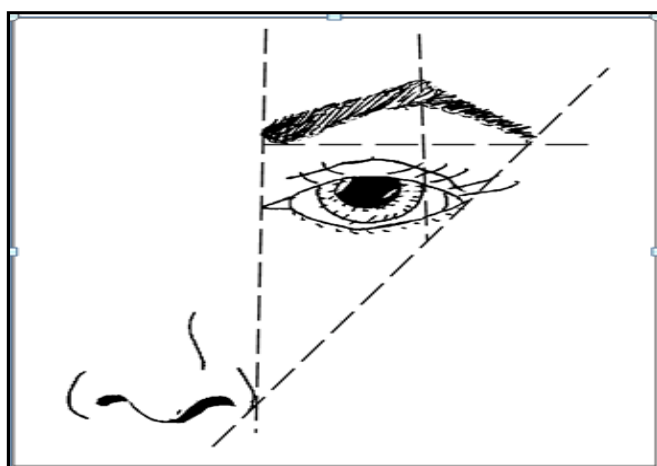


Fig 2: Westmore's method of eyebrow aesthetics to ascertain the tail of eyebrow



Fig 3: Application of Westmore's method in cadaver to ascertain tail end of eyebrow and the *Apanga marma* below it

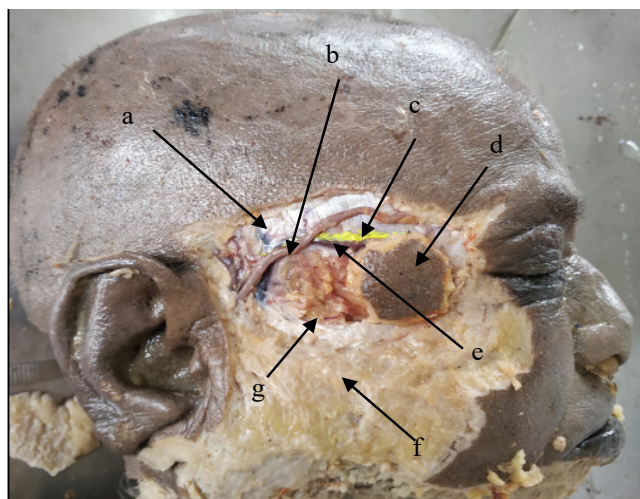


Fig 4: Structures observed in between superficial and deep layers of temporal fascia . a- Temporal fascia (Superficial layer). b- Superficial temporal artery. c- Zygomaticotemporal nerve. d- Apanga marma area. e- Zygomatico-orbital artery. f- Superficial fascia g- Adipose tissue

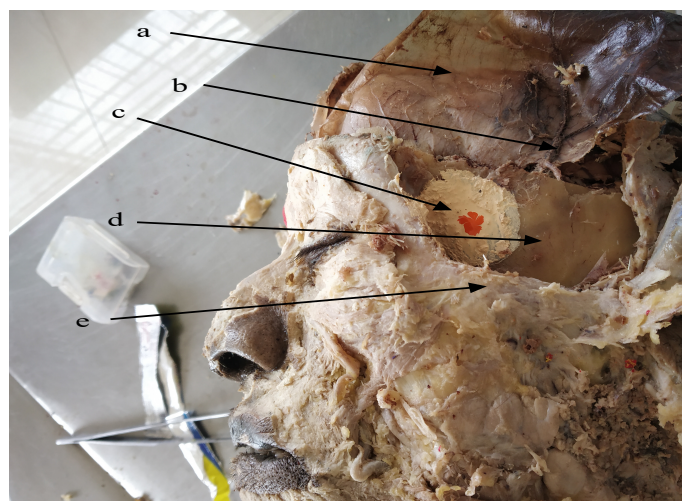


Fig 5: Marking of Apanga marma on the bony wall of superior temporal fossa after removing Temporalis muscle. a- Dura matter b- Middle meningeal artery c- Marma area d- Temporal bone e- Zygomatic arch

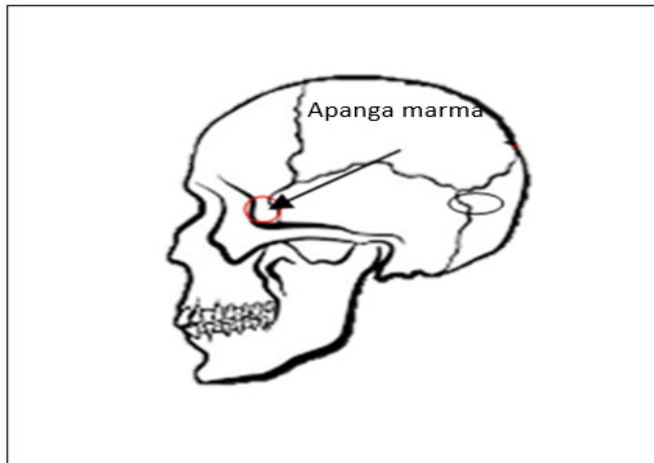


Fig 6: Marking of Apanga marma on the bony wall of superior temporal fossa.

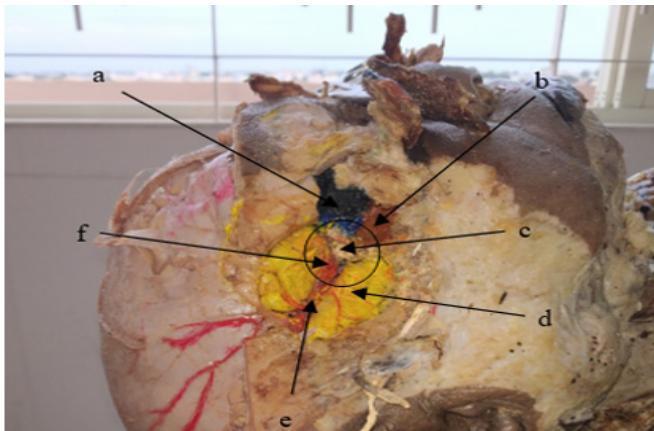


Fig 8: Structures observed after removing dura matter. a-Lacrimal gland b-Lateral rectus c-Sphenoid bone d-Temporal lobe of cerebrum e-Lateral sulcus f-Middle cerebral artery

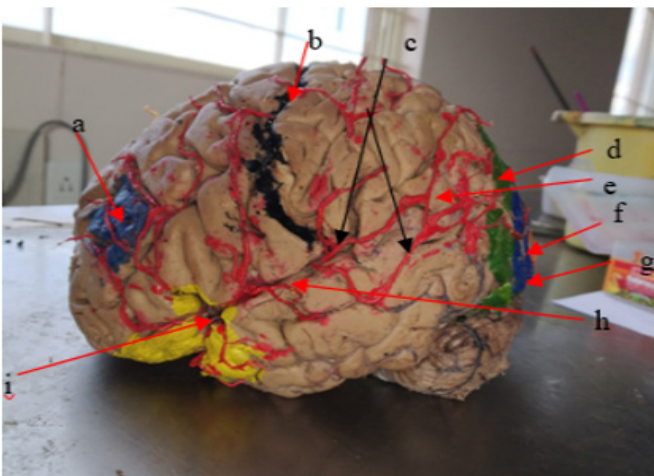


Fig 10: Cortical branches of Middle cerebral artery (MCA) supplying areas related to vision. a-Frontal eye field. b-central sulcus. c-Cortical branches of MCA d-Visual association area 19. e- Higher visual association area. f-Primary visual area 17. g-Visual association area 18. h-Posterior ramus of lateral sulcus. i-Sylvian point

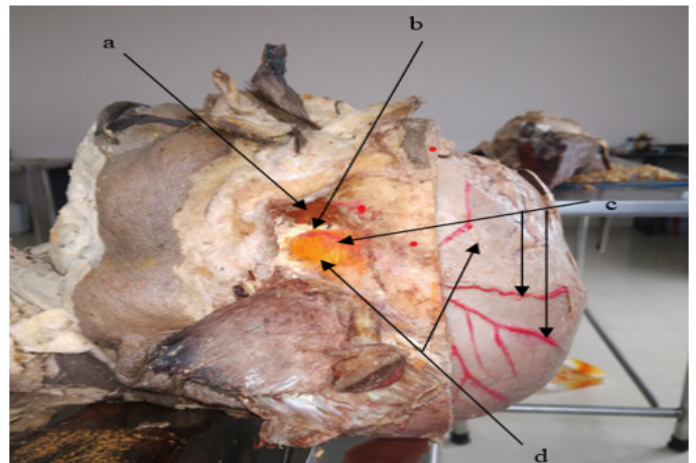


Fig 7: Structures observed after removing bony wall. a- Bulbar fascia b- Sphenoid bone forming lateral orbital wall c- Middle meningeal artery & branches d-Dura matter

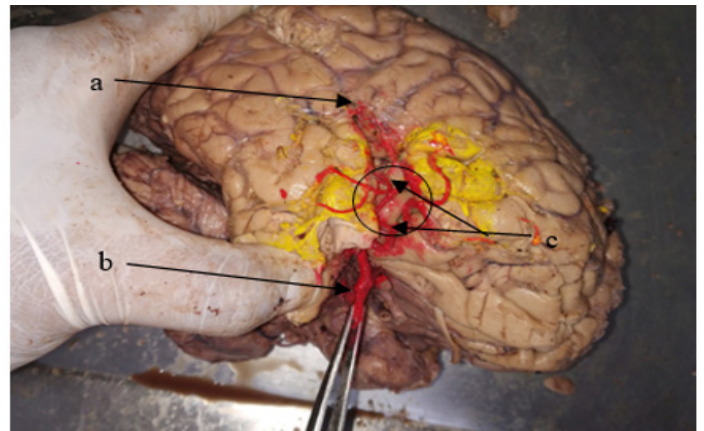


Fig 9: Structures observed at Sylvian point. a-Posterior ramus of lateral sulcus b-Middle cerebral artery & its cortical branches c- Internal carotid artery

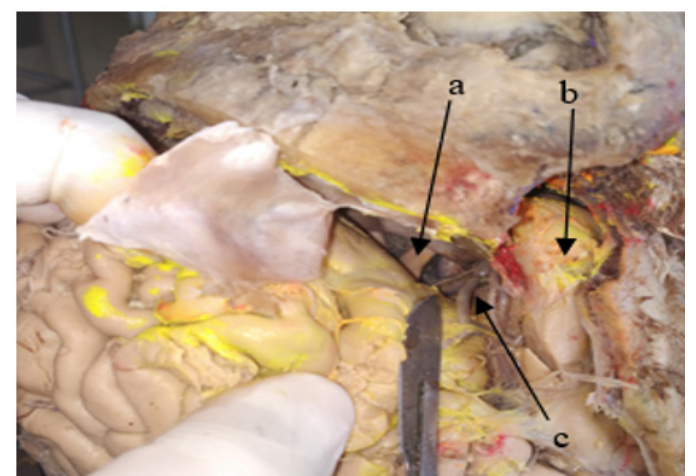


Fig 11: Structures at the depth of marma area. a- Optic nerve b-Temporal lobe c-Middle cerebral artery

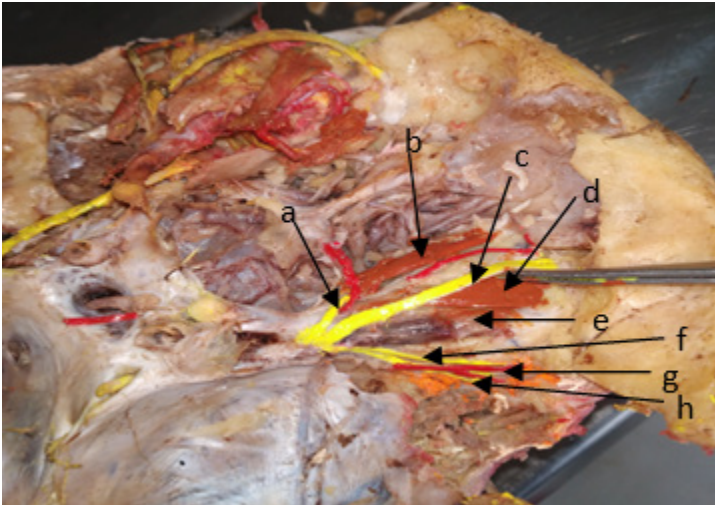


Fig 12: Structures present deep to the orbital fascia a- Trochlear nerve b- Superior oblique muscle c- Frontal nerve d- Levator palpebrae superioris e- Superior rectus f- Lacrimal nerve g- Lacrimal artery h- Abducent nerve