Anomalous Origin Of The Middle Meningeal Artery—A Review.

Manjunath, K.Y.

Department of Anatomy, St. John’s Medical College, Bangalore - 560 034

Abstract. Middle meningeal artery (MMA) is the largest and most important of the arteries supplying the meninges. It is usually a branch of the first part of maxillary artery. However other sources of its origin have been described in literature viz : third part of maxillary artery, ophthalmic artery, persistent stapedial artery, internal carotid artery, basilar artery and rarely ascending pharyngeal artery. These anomalous origins of MMA are of clinical significance in cases of fractures of the squamous and petrous temporal bone, and in surgical interventions involving Vidian nerve or the ligation of the middle meningeal artery. Literature on the incidence of the variations of the origin of the MMA and their embryological basis is reviewed here.

Key words: Dural vascularization, Arterial variations, skull, Head injuries.

Introduction :

The middle meningeal artery (MMA) is the largest of the several meningeal arteries; it is also by far the most important branch of the maxillary artery as it is a frequent source of haemorrhage after injury to the skull. The MMA is usually a branch of the first part of the maxillary artery. Other sources of its origin and course have been described in the literature. These variations are of clinical significance in fractures of the squamous and petrous parts of the temporal bones and surgical interventions involving the nerve of the pterygoid canal and maxillary artery (Klisovic, Sikic and Krmptotic-Nemanic 1993).

Sources of anomalous origin of the MMA :

1. In the absence of foramen spinosum the MMA may enter the middle cranial fossa through the foramen ovale along with the mandibular nerve (Bartlett 1902 ; Chandler and Derezinski 1935).

2. The MMA may arise as a branch of the third part of the maxillary artery (sphenomaxillary portion) and enter, the middle cranial fossa through the lateral end of the superior orbital fissure (SOF) (Toida 1934; Low 1946).

3. The MMA may partially (i.e. only the anterior branch) or completely arise from the ophthalmic artery. Under such circumstances it passes through the lateral end of the SOF or a foramen in the greater wing of the sphenoid (foramen meningo-orbitale). The MMA of ophthalmic origin is known as the ophthalmic middle meningeal artery (OMMA). Earliest cases of the OMMA were reported by Curnow (1874) and Zuckermandl (1976) (cited by Royle and Motson- 1973; McLennan, Rosenbaum and Haughton-1974).

4. Rarely MMA may arise as a branch of the persistent stapedial artery (PSA). The PSA is usually a branch of the intrapetrous portion of the internal carotid artery, enters the tympanic cavity through its floor and passes through the obturator foramen of the stapes. For a short distance it is enclosed in a bony canal over the promontary and enters the facial canal, and emerges in to the middle cranial fossa under the dura and gives off the middle meningeal branch (Altmann 1947). The MMA of stapedial origin is called the stapedial middle meningeal artery (SMMA). The first case of PSA was described by Hyrtl in 1836 (McLennan et al 1974).

5. The MMA can also originate from prepetrous and suprasellar portion (extradural portion of the carotid siphon) of the internal carotid artery. (Newton and Potts 1974, Dileenge and Ascherl 1980).

6. The MMA may also arise as a branch of the intra cavernous portion (juxtasellar) of the internal carotid artery (Newton and Potts 1974, Tran-Dinh and Jayasinghe 1983).

7. Some authors have reported anomalous origin of MMA from the basilar artery (Seeger and Hemmer 1976 ; Waga, Okada, Yamamoto 1978; Katz Wisoff, Zimmerman 1981).
8. A rarest instance of MMA arising from the ascending pharyngeal artery also has been reported (Moret, Lasjaunias, Vignaud, Doyon 1978).

With the advent of the angiographic technique more and more cases of anomalous origin of the MMA are being reported in the literature.

**Embryological basis:**

The available embryologic literature on the development of the cranial arteries suggests a fundamental relationship between the development of the ophthalmic and middle meningeal arteries, and the embryonic stapedial artery (Dilenge and Ascherl 1980). Knowledge concerning the early development of the stapedial artery is obscure, but however some observations by Tandler (1902), Evans (1912) and Padget (1948) [summarised from Dilenge and Ascherl 1980] permits some assumptions (see fig.1): The stapedial artery is formed by the union of the remnants of the first branchial arch with the hyoid artery. After having penetrated the ring of the stapes it divides into two definitive divisions:

1. A maxillofacial division consisting of an infraorbital and a mandibular branch.
2. A supra orbital division consisting of branches destined to supply the orbit and the intracranial segment of the MMA. The branches of the maxillofacial division are assimilated by the developing external carotid artery and forms the maxillary artery (including the extracranial part of the MMA). At this stage the proximal part of the stapedial artery involutes, and its remnants become the tympanic branches of the MMA.

The supra orbital division of the stapedial artery forms in addition to the extraocular intra orbital arteries, the intracranial segment of the MMA. After the intraorbital branches of the stapedial artery are assimilated by the ophthalmic artery its proximal intra and retro orbital branches involute and become resorbed by the intracranial segment of the MMA.

**Origin of the MMA from the petrous segment of the internal carotid artery:**

The basis of this anomaly is persistence (failure of involution) of the embryonic stapedial artery. This artery has been the subject of numerous anatomic dissections (Hyrtl 1936; Alexander 1849; Brock 1922 cited by Marion, Hinojosa, Khan 1985; Davies 1967), and has been reported to be observed by chance, in three occasions during middle ear surgery (Baron 1963; House and Patterson 1964). While naturally present in adult rodents and some bats, PSA in man is a rarely reported anomaly. Rarity of this anomaly can be appreciated by the fact that House and Patterson (1964) encountered this anomaly only twice during 8,000 procedures on the middle ear, whereas, Steffen (1968) noticed only two cases during 10,000 middle ear operations. First reported by Hyrtl in 1836, only around thirty cases of this anomaly have been documented in the past 165 years of its history (see Table 1). Guinto, Garrabrant and Radcliffe (1972), were the first to report the angiographic features of PSA. The course of the PSA has been well documented by Altman (1947). When present, it can pose a technical problem during stapes surgery (Guinto et al 1972). A large PSA has been frequently reported in association with other anomalies: anencephaly and Paget’s disease (Altman 1947); multiple congenital anomalies (Keleman 1958; Sando, Baker and Black 1972 cited by Marion et al 1985); thalidomide child (Maran 1965 cited by Marion et al 1985); first arch anomaly (Pascual-Castrovejo 1983).

**Ophthalmic origin of the MMA (OMMA):**

Two separate processes are involved in this anomaly:

1. Failure of the proximal intra orbital and retro orbital stapedial branches to involute, so that the intracranial segment of the MMA remains connected with the intraorbital stapedial branches.
2. Defective involution of the maxillofacial division of the stapedial artery so that the extracranial segment of the MMA is never formed. As a result, no connection forms between the maxillary artery and the Middle Meningeal Artery.
intracranial segment of the MMA (Dilenge and Ascherl 1980).

The ophthalmic origin of the MMA is a relatively frequent anomaly. Dilenge and Ascherl (1980) found 17 cases of MMA arising from the ophthalmic artery among 3,500 cerebral angiograms examined by them (0.5%). Earliest cases of MMA arising from the ophthalmic artery have been described by Curnow (1874) and Zukerkandl (1876). Royle and Motson (1973) have described a case of bilateral origin of the MMA from the ophthalmic in an adult skull of Asiatic origin, which is probably the first photographic record of this anomaly. Gabriele and Bell (1967) consider their report of three cases of ophthalmic origin of the MMA as the first arteriographic demonstration of this anomaly.

Instances of partial origin of MMA (only the anterior branch) have been reported previously: Toida (1934) in his study of 192 Chinese skulls found five instances of anterior branch, and only one instance of the complete stem of the MMA originating from the orbit (Low 1946). Chandler and Derezinski (1935) in their study of 1200 sides of the skull found only one instance of the anterior branch of the MMA arising from the orbit. Klisovic et al (1993) found 1% incidence of the cases of partial origin of the MMA from the ophthalmic artery in their study. Embryological basis of this partial origin of the MMA from the ophthalmic is, that sometimes the extracranial segment of the MMA forms normally and unites with the intracranial segment, with only partial involution of the retro orbital stapedial branches so that some connection with the MMA is maintained (Dilenge and Ascherl 1980). Under such a circumstance the anterior branch originates from the ophthalmic and the posterior from the maxillary artery. According to Falk and Nicholls (1992), the anterior branch of the MMA of humans is homologous with the meningeal lacrimal artery of rhesus monkeys. All three of the homologues, derive (developmentally) from the ophthalmic artery, and supply the same region of the skull and dura mater. The difference is that the homologous artery is usually distinct from the MMA in monkeys and apes, but has become incorporated as the anterior branch of the MMA in humans. Incidence of the posterior branch of the MMA alone arising from the ophthalmic artery has also been described (Newton and Potts 1974).

A large meningeal branch originating from the lacrimal artery has been observed in angiograms in cases of pterional meningiomas. Such branches are pathological and serve only as a feeder vessel to the tumour in that region (Galligioni, Pallone, Bernardi, Iraci 1967). Origin of the MMA from extradural part of the carotid artery is quite rare (see table 1). A possible embryologic mechanism relates to an aberrant origin of the hyoid artery from the internal carotid artery, so that its union with remnants of the first branchial arch to form the stapedial artery either does not occur or occurs with out any relation to the level of the stapes (Dilenge and Ascherl 1980).

Only a few cases of the MMA arising from the basilar artery have been reported (Seeger and Hemmer 1976; Waga et al 1978; Katz et al 1981). The embryology of this anomaly has not been described and is only speculative. Waga et al (1978) feel that this anomaly is due to an anastomosis between the trigeminal artery and the PSA.

Relationship of the foramen spinosum to the anomalous origin of the MMA:

Absence of the foramen spinosum often accompanies aplasia of the conventional MMA. Substitution of the MMA by the OMMA or PSA would also be expected to result in the absence of this foramen. A small foramen spinosum suggests hypoplasia of the conventional MMA; under such circumstances, a second source of the meningeal blood supply should be sought (McLennan et al 1974). McLennan et al (1974) in their examination of 108 dried skulls found only one skull with bilateral and another with unilateral absence of foramen spinosum. Low (1946), Royle and Motson (1973) have also noticed bilateral absence of the foramen spinosum in their report of the anomalous origin of the MMA, from the orbit. The evolution of selective and even subselective cerebral angiography, coupled with continued refinement in angiographic imaging apparatus and subraction technique, has permitted remarkable progress in ability to resolve vascular anatomy (Dilenge and Ascherl 1980). Selective catheterisation of branches of the
common carotid artery has facilitated the angiographic demonstration of anomalous origin of the MMA (Mclennan et al 1974). Around fifty cases of the MMA of ophthalmic origin have been reported so far (see Table-I).

### Table 1
Case Reports of The Anomalous Origin of The Middle Meningeal Arterty

**Source of the anomalous MMA**

**Authors (Year; material observed* no. of cases)**

I. **3rd part of Maxillary artery** : (1) Low (1946-a-I)


Nos. 1,2 cited from No. 9; Nos. 3, 4, 7 cited from No. 8; No-5 from No. 6


Nos 2, 3, 4, 7, 9, 10, 14 are cited from Marion et al. - No. 21

(b) *Intra cavernous part (Juxtasellar)* (1) Newton and Potts (1974-c-1) (2) Tran-Dinh & Jayasinghe (1983-c-1)

(c) *Prepetrous & Suprasellar part* (1) Newton and Potts (1974-c-1) (2) Dilenge and Ascherl (1980-c-1)


V. **Ascending pharyngeal artery** : (1) Moret, Lasjaunias, Vignaud, Doyon (1978-c-1)

*Material observed:- (a) dry skulls, (b) cadaver/postmortem dissection/clinical case (c) angiography. **indicates material observed/number of cases not known.

Unlike the MMA of stapedial origin there have been no reports of a case of MMA of ophthalmic origin presenting with clinical symptoms. Anomalous origin of the MMA from the third part of the maxillary artery or the ophthalmic is of surgical interest beause it would be difficult to ligate its main trunk, Since it will not be found in its normal place in comparison to the conventional MMA located in the floor of the middle cranial fossa, where it would be within easy access (Low 1946, Klisovic et al 1993).

**References**:


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Fig 1: (1-4) 1- shows the stapedial artery (sta) arising from the internal carotid artery and dividing into, supra orbital (SO) and maxillofacial (MF) divisions. 20mm stage embryo. 2-maxillofacial and middle meningeal arteries (MMA) have been assimilated into external carotid artery (ECA) to form the maxillary artery (MAX); supra orbital division (SD) has united with the ophthalmic artery (OA)- following the involution of the stapedial artery. 3- The middle meningeal artery (mma) being given off by the persistent stapedial artery (sta). 4- The intracranial part of the MMA has become annexed to the ophthalmic artery giving rise of ophthalmic middle meningeal. [based on the descriptions from, Davies 1967; Dilenge and Ascherl-1980; Marion. Hinojosa, Khan-1985].