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The variant relationship of the maxillary artery to the lateral pterygoid muscle: a cadaveric study

Abstract

Study objective: To describe the variations and anatomical landmarks of the maxillary artery

Study design and population: This was a descriptive cross-sectional cadaveric study, carried out in the department of human anatomy at the University of Nairobi.

Study duration: This was conducted between November 2015 and May 2016.

Material and methods: Ninety three (93) hemi-sections from 48 cadavers were used for the study. Dissection of the infratemporal fossa was done to expose the MA and its branches on both sides. The distance of the MA from the articular eminence, mandibular neck, mandibular notch and pterygoid fovea were recorded. The relationship of the MA with the LPM and its branching pattern noted.

Results: Out of the 93 hemi-sections dissected 67% of the MA were within the parotid gland while 33% were medial. Thirty five of the MA had a medial relationship to the LPM while, 58 were lateral. Six (6.5%) hemi-sections had the middle meningeal artery (MMA) and the inferior alveolar artery (IAA) originating from a common trunk on the MA. The accessory meningeal artery (AMA) was absent in 3 (3.2%) hemi-sections on the right side and in 2 (2.2%) on the left. Amongst all distances measured of the MA to the bony prominences; mandibular notch, condylar neck, articular eminence, the Pterygoid fovea (14.61±7.07mm for the left and13.93±6.17 and the right side) was the most reliable.

Conclusion: The relationship of the MA is more lateral than medial. The most reliable bony landmark is the pterygoid fovea. The branching pattern of the IAA and MMA off the MA is inconsistent in different studies. The MA is a very variable and tortuous artery, probably influenced by age, gender and ethnicity.

Keywords: Maxillary Artery, Lateral Pterygoid Muscle, Bony landmarks, Variations, Cadaver

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Introduction

The Maxillary artery (MA) is a large terminal vessel of the External carotid system and is divided into 3 relative to its position with that the lateral pterygoid muscle (LPM). The mandibular part is posterior to the lower border of the muscle, pterygoid, and the perygopalatine part is in the perygopalatine fossa. The following structures are supplied: the cranial dura mater, nose, palate, maxilla, mandible, teeth and muscles of mastication.[1] The course of the MA and it's relation to the LPM has been studied in detail in various populations.[2,3] Depending on the population and gender being studied the MA in relation to the LPM may be either medial or lateral in position for example amongst the Caucasians, Turkish, Japanese and Indians it has been reported to more lateral than medial.[4-7] It was found on the medial side of the LPM in white individuals and in 31% of an African American population by Lasker et al.[2]

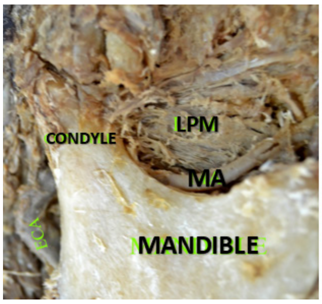
Procedures close to Temporal mandibular joint, Parotid gland and pseudoaneurysm that may require embolization of the MA and its branches. The proximity of the vessel and in addition to its variations present in the general population increases the risk of inadvertent injury during surgery.[8-11] Literature search was scarce for the variations of the MA and its branching patterns for the African population, hence the study was done in a select Kenyan population.

Materials and methods

The study design was descriptive cross section, ninety three (93) hemi sections from 48 formalin embalmed cadavers were included from the Department of Human Anatomy, University Of Nairobi. Of the forty eight (48), 3 had the left side disfigured by medical students and therefore had to be excluded. The Kenyatta National Hospital/ University of Nairobi (KNH/UoN) Ethics and Research Committee had approved the study (P660/10/2015). Exposure of the Parotid gland and the Masseter was done via a preauricular incision and the skin was reflected anteriorly. The superficial lobe and the muscle were sacrificed for exposure of the mandibular condylar region. Identification of the ECA was done in the neck and followed up to origin of the MA. Using an oscillating saw exposure of the MA lying in the infratemporal fossa was done by osteotomy of the zygomatic arch and the ramus. The MA was followed from its origin and its relation with the LPM recorded. Perpendicular distances between the MA and bony prominences (The most inferior part of the mandibular notch, posterior cortex of the center of the mandibular condylar neck, inferior part of the articular eminence and the inferior border of the pterygoid fovea were measured in millimeters using vernier calipers. All the measurements were repeated three times and checked by both the principle investigator and one other member of the research team as a control for intra-examiner variability. Data was coded and analyzed using the Statistical Package for Social Science (SPSS) version 17.0 and presented in tables and graphs. Chi square for nonparametric data and paired student's t test for parametric data was used to test the level of significance.

Results

The study population consisted of 53 cadavers, of which forty six (46) were male and two (2) females. Five (5) cadavers were excluded as 3 were desiccated and 2 had deep scarring. Out of the 48 cadavers, 3 had the left sides mutilated, the result was 48 right and 45 left hemi sections were included for data collection. As there were gender imbalance due to the few numbers of female cadavers gender differences could not be factored. The MA had a lateral 58 (62%) relationship and 35 (38%) was medial to the LPM (Figure 1A & 1B). Relative to the LPM the MA was lateral in position in ≈60% than medial ≈40%, the same relationship was for the right and left side of the cadaver (Table 1).



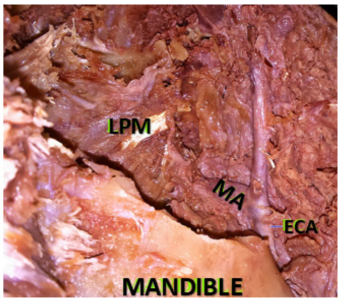


Figure 1A **Figure 1B**

Figure 1A Photomacrograph of the right side of the face showing maxillary artery passing lateral to the lateral pterygoid muscle.

Figure 1B Photomacrograph of the left side of the face showing the maxillary artery passing medial to the lateral pterygoid muscle. ECA, External carotid artery.

Table 1 Relationship of the MA to the LPM

Description	Right side n (%)	Left side n (%)	Total n (%)	Chi square p<0.05
Medial to LPM	17 (35)	18 (40)	35 (38)	0.029
Lateral to LPM	31 (65)	27 (60)	58 (62)	0.017
Total	48	45	93	

The origination of the MMA and the IAA from the MA was from the same point in 6(6.5%) of the population, the AMA was absent in 3(3.2%) cadavers on the right and in 2(2.2%) on the left. However, on the right the branching pattern was different, the MMA branched off from the MA before the IAA in 18(37.5%) of the cadavers and in 27(56.3%) of the hemi-sections it emerged after the IAA (Figure 2) (Table 2). The MMA on the left was observed to be given before the IAA in 10(22.8%) and in 32(71.1%) after the IAA (Figure 3). In all the hemi-sections the IAA originated directed from the MA. In only one case the two IAAs originated, one vessel entered into the mandibular canal and the other accompanied the nerve to innervate the mylohyoid muscle. The other pattern reported were of the deep auricular artery and the anterior tympanic artery emerging from the same stem of the MA. It was surprising that the deep auricular artery was much larger in size than expected. On the right the MMA and AMA emerged from the same trunk off the MA in 28(58.3% of the cases (Table 1). In 25(55.6%) MMA and AMA originated from the same trunk of the MA on the left side of the hemi sections (Figure 3). The origin of the MMA and the AMA showed asymmetry in its origins, in 4(8.3%) it originated from one side of the trunk while, separately on the other side.

Table 2 Pattern of origin of the MMA and the IAA from the MA

Description		Right n (%)	Left n (%)
The MMA	Branching before the IAA	18 (37.5)	10 (22.8)
	Branching after the IAA	27 (57.4)	32 (71.1)

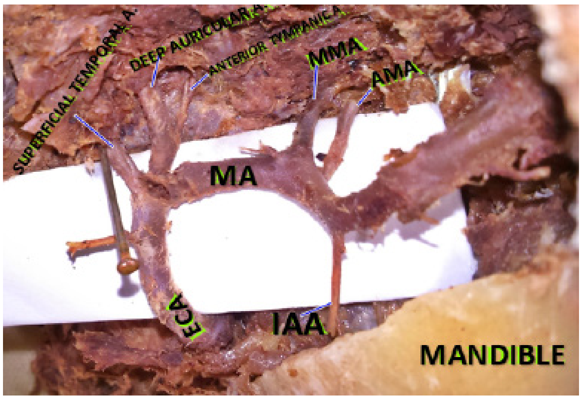


Figure 2 Illustration of the branching pattern of the 1st part of the right MA. The inferior alveolar artery (IAA) branching after middle meningeal artery (MMA). Separate origin of MMA and the accessory meningeal artery (AMA). Note also an abnormally large deep auricular A.

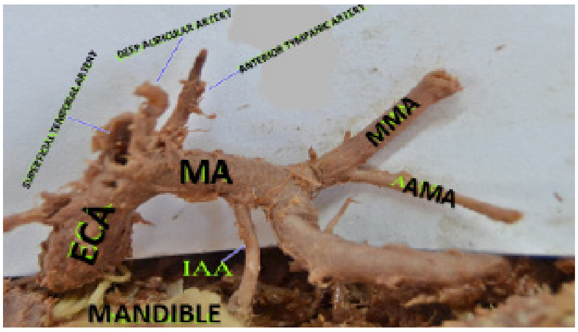


Figure 3 Illustration of the inferior alveolar artery (IAA) originating before the middle meningeal artery (MMA). Photomacrograph showing the inferior alveolar artery (IAA) originating before the middle meningeal artery (MMA). Also the MMA and the accessory meningeal artery (AMA) are given off from a common trunk from the maxillary artery (MA).External carotid artery (ECA).

The average measurement from the most inferior part of the mandibular notch on the right was 5.72±2.82 mm (mode = 5.25 mm) and on the left 5.80±2.85 mm (mode of 5.75 mm). The measurement from the posterior cortex at the center of the condylar neck of the mandible on the right was 8.39±2.67 mm (mode =6 mm). On the left was 8.39±2.67 mm (mode =6 mm) and on the left the average was measured as 8.78±2.70 mm (mode =3.60 mm). The mean distance of the MA to the inferior region of the pterygoid fovea on the right was 13.93±6.17 mm; (mode =7.25 mm), on the left side was 14.61±7.07 mm (mode =5.25 mm). From the inferior part of the articular eminence the MA was on the right an average of 14.05±3.77 mm (mode = 6.62 mm) while, on the left it was 14.47±4.01 mm (mode =14.25 mm). None of the measurements of the MA and the bony landmarks were not statistically significant (Table 3).

Table 3 Variations in origin of the MMA and AMA

	Right side (%)	Left side (%)	Total n (%)	Chi square p<0.05
The MMA and AMA common trunk off the MA	28 (58.3)	25 (55.6)	53 (57)	0.144
The MMA and the AMA given separately off the MA	17 (35.4)	18 (40)	35 (37.6)	0.144
The AMA missing	3 (3.2)	2 (2.2)	5 (5.4)	

Discussion

While performing surgery in the craniofacial region, knowledge of the variant anatomy of the MA may help in inadvertent injury and intraoperative hemorrhage. Sixty seven percent (67%) of the MA were noted to branch within the parotid gland in this study ($X^2_{df=1}$=10.3; p =0.001), in comparison to 33% which branched medial to the gland ($X^2_{df=1}$=9.0; p=0.003). The relationship enables the surgeon to protect the vessel and therefore, avoid bleeding during parotidectomy. The MA is lateral to the LPM as reported in 9 - 55% and 90% in the white and Japanese respectively and similarly in this study the artery was found lateral in 58 (62%) ($X^2_{df=1}$=5.7; p = 0.017) and medial in 35 (38%) ($X^2_{df=1}$=4.7; p =0.029).[11] This is in tandem to other studies other population groups Caucasians, Turkiyens, Asians, Japanese and Indians, Koreans, American, Russian.[3,4,6,7,12-16] Comparison of studies sometimes becomes challenging as some data is from fresh and others formalin fixed cadavers as was one of the limitation of this study. Formalin fixed cadavers tends to desiccate tissues and may alter the measurements to a certain degree.

Using three-dimensional time of flight magnetic resonance angiography imaging on 300 individuals the course of the MA to the LPM was lateral in 54.3% and medial to 45.&% comparable to the proportion reported in other European studies. Amongst the study population MA had an asymmetric course in 22% women (29 women and 37 men).[17] Thirty eight percent (38%) of the population in our study the MA had a medial relatioship to the LPM similar to the study done by Lasker et al., (31% of the African Americans) and (32% Caucasians).[2,4] Symmetry was noted in both the left and right sides of the cadavers in the course of the MA except in 4(8.5%) where there was asymmetry, the artery passed medial to the LPM on one side and lateral on other. It appears that the relationship between the MA and LPM is erratic, however, the artery is known to be lateral to the muscle, and blunt dissection is best used to identify the ptergoid part. The MA can be ligated before a maxillectomy to reduce the risk of bleeding due to the intimate relationship of the vesssel and the mandibular subcondylar area. This relationship differs depending upon on race and Ethnicity.[18,19] The relationship of a tumour in close proximity to the LPM is evident with patients presenting with trismus. In addition there is compression of the MA as it lies between the two heads of the muscle tends to interfere with blood supply of the nasal region.[6] MA and its branches are ligated in patients who present with persistent epistaxis. In addition caution is exercised during administration of dental anesthesia to avoid intra-arterial injection, the vessel can be a cause of inadvertent bleeding during excision of tumors in the infratemporal fossa.[20]

Different key bony landmarks have been studied in locating the MA which acts as guide to prevent injury during osteotomies. The mandibular notch and the MA are at a distance of 5.76±2.82 mm consistent which other reports.[1,6,7] The mean distance of the artery and the articular eminence 1.67±0.48 mm (n=34), a variation from Balcioglu et al., where the averages were 14.25±3.87 mm. However, in this group the distance of the pterygoid fovea to the MA was 14.21±6.61 mm, which was consistent with a study done by Balcioglu et al.,[21] Few cadaveric studies have focused on the risk of the MA injury during mandibular osteotomies and hardly any on the black population.[12,23] IAA a branch of the MA is the main source of blood supply to the mandible. It branches of the of the MA rarely originates from the ECA.[24,25] IAA in this study was noted to branch directly from the MA in all cadavers. An interesting point to note was that IAA branched prior to MMA in 59 (63.4%) of the hemi-sections, and after the MMA 28 (30.1%). It branched at the same origin of the MMA in 6 (6.5%) hemi sections. Uysal et al.reported a lower finding, of 35.7% of the cases the IAA arose from the MA before the MMA while, in 35.7 % it was given off after the MMA.[6] Otake et al., found that the IAA arose distal to the MMA in 25 of 28 hemi sections (89.3%).[3] The IAA and the MMA branched off from the same area of the MA in 14.3 % of the cases while in others, the IAA branched off from the beginning of the MA in 14.3% of the cases.[6] The MMA was present in all cadavers and the AMA in 57.1% as documented by Uysal et al.,[6] In this study the AMA was found to be missing in 3(6.3%) cadavers on the right side and in 2 (4.4%) cadavers on the left side. A variation was presented by Rao et al., the anterior tympanic and the AMA arose from the MMA.[26] In this study the AMA and MMA, branched from the MA common trunk in 53 (57%) of the hemi-sections. This finding has been reported by Otake et al. to be as low 18 (64.3%) and as high as 73 of 76 subjects (96%) by Baumel et al.[3,27] (Table 4).

Table 4 Comparison of the measured distances between the right and the left side in relation to selected bony landmarks

Bony landmarks	Mean	Median	Minimum	Maximum	95 % confidence interval of the difference		Paired student's t Test
	Distance (mm)±SD(mm)	Distance (mm)	Distance (mm)	Distance (mm)	Lower	Upper	P value <0.05
Distance of MA from inferior most part of mandibular notch on the right side (N=48)	5.72±2.82	5.44	1.03	14.76	-0.64402	0.12947	0.187
Distance of MA from inferior most part of mandibular notch on the left side(N=45)	5.80±2.85	6	0	14			
Distance of MA from posterior cortex at the center of condylar neck of the mandible on the right side(N=48)	8.39±2.67	8.3	3.87	18.27	-0.93597	0.16143	0.162
Distance of MA from posterior cortex at the center of condylar neck of the mandible on the left side (N=45)	8.78±2.70	9.15	3.6	17.81			
Distance of MA from inferior of articular eminence on the right side (N=48)	14.05±3.77	14.19	6.62	21.48	-1.53776	0.25185	0.155
Distance of MA from inferior part of articular eminence on the left side (N=45)	14.47±4.01	14.38	6.5	24.08			
Distance of MA from inferior part of pterygoid fovea on the right side (N=48)	13.93±6.17	11.7	4.94	24.5	-1.50507	0.23689	0.149
Distance of MA from inferior part of ptrerygoid fovea on the left side (N=45)	14.61±7.07	13.38	3.98	26.76			

Conclusion

The relationship of the MA is more lateral than medial. The most reliable bony landmark is the pterygoid fovea compared to the others (articular eminence, mandibular notch) which have been more variable. The branching pattern of the IAA and MMA off the MA is inconsistent in different studies as has been shown. The MA is a very variable and tortuous artery, this is influenced by age, gender and ethnicity. It is important to document this variant anatomy of the MA with respect to the bony landmarks in order to provide reliable check points when operating in the infra temporal fossa.

Acknowledgments

None.

Conflicts of interest

None.

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