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Morphometric Analysis of the Maxillary Artery and Occurrence of Syntopies with Anatomical Landmarks

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ABSTRACT

Introduction: the aim of the present study was to determine the occurrence of syntopies between the maxillary artery (MA), the inferior alveolar nerve (IAN), the lingual nerve (LN), and the lateral pterygoid muscle (LPM); in addition, we also measured the trunk of the maxillary artery and its distance to anatomical landmarks. A cross-sectional study was performed with 35 hemifaces. Statistical analysis was performed on GraphPad Prism 6.01 (significance level and confidence interval set at 5% and 95%, respectively). The MA was predominantly located laterally to the IAN (R= 94,11%; L = 100%; p>0.05) and always located laterally to the LN (100% of cases, on both antimeres; p>0.05). The MA was mostly located superficially to the LPM (R= 83,33%; L= 88,23%; p>0.05). The mean thickness of the trunk of the MA on the cranio-caudal axis was of 2,23+/- 0,48mm (R) and 2,37+/- 0,65mm (L); and on the latero-medial axis of 1,76+/-0,39mm (R) and 1,72+/-0,49mm (L). The mean distance of the MA to the crest of the articular eminence was of 27,38+/-4,39mm (R) and of 26,84+/-4,46mm (L). All the aforementioned morphometric data showed non-significant results (p>0.05) when sides were compared. The mean distance between the MA and its first visible branch was of 11,78+/-5,79mm on the right side and of 8,44+/-5,99mm on the left side (p<0.05).
Keywords: Maxillary artery; Mandibular nerve; Infratemporal fossa; Morphometry; Anatomy.

Introduction

The maxillary artery (MA) is the thickest branch of the external carotid artery. It begins at the level of the mandibular neck, courses horizontally through the infratemporal fossa, medially to the mandibular ramus, and runs anteriorly towards the maxillary tuberosity, where it curves medially and slightly superiorly to reach the pterygopalatine fossa[1,2]. During its course through the infratemporal fossa, the MA may be located superficially or deeply to the lateral pterygoid muscle[3].

The inferior alveolar nerve (IAN), by its turn, originates from the mandibular nerve (NC V_3) on the infratemporal fossa and enters the mandibular foramen on the medial aspect of the mandible; then, it courses through the mandibular canal and ends dividing into the incisive and mental nerves. Its branches are responsible for the sensitive innervation of all teeth and part of the periodontium on the ipsilateral inferior hemiarch[4].

The lingual nerve (LN) constitutes the medial most part of the posterior division of the mandibular nerve. It is initially located medially to the lateral pterygoid muscle, running parallel to the IAN and then medially and anteriorly to the same nerve when both are located at the level of the middle third of the mandibular ramus. The space between the lateral pterygoid muscle and the mandibular ramus (i.e. the pterygomandibular space) is the location of choice to reach it to block these nerves[5].

Scientific literature lacks data regarding the percentage of occurrence on the possible types of anatomical patterns between the MA and the inferior alveolar and lingual nerves, as well as regarding morphometrical data on the relation between the MA and anatomical landmarks. This knowledge may be of use for clinicians and surgeons on procedures such as anesthetic techniques, diagnosis and treatment of pathologies, and surgical access to the infratemporal fossa[6-8].

The aim of the present study was to determine the occurrence of syntopies between the maxillary artery, the inferior alveolar nerve, the lingual nerve, and the lateral pterygoid muscle; in addition, we also measured the trunk of the maxillary artery and its distance to anatomical landmarks.

Materials and Methods

Ethical considerations and sample

In conformity to the Brazilian Federal Law 8.501 of November 30, 1992, and after institutional approval, a cross-sectional study was performed with 35 hemifaces previously fixed in 10% aqueous formaldehyde solution or in 98% glycerin. Hemifaces pertained to the Human Anatomy Division of the Institute of Biological and Health Sciences (Federal University of Alagoas, Maceió,

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Alagoas, Brazil) and were not specified according to age or gender of the donor; however, they all were of adult individuals.

Inclusion criteria were: hemifaces with the infratemporal fossa previously dissected and with integrity of the maxillary artery, the inferior alveolar nerve and the lingual nerve. Hemifaces with partial or complete absence of the anatomical structures of interest were excluded, as well as specimens in which the quality of the dissected structures was not sufficient for proper data acquisition.

Of the 35 hemifaces that were assessed for eligibility, 34 were selected to study the syntopy between the MA and the IAN, 26 were selected to study the syntopy between the MA and the LN, 30 were selected for the morphometric analysis of the MA, and 35 hemifaces were selected to study the relation between the MA and lateral pterygoid muscle.

Variables

The variables of the present study were the following:

1) Occurrence of the relation between the maxillary artery and the inferior alveolar and lingual nerves, categorized as medial, lateral, or in "S" (i.e., medial to one nerve and lateral to the other one);

2) Occurrence of the relation between the maxillary artery and the lateral pterygoid muscle, if superficially or deeply positioned to it;

3) Thickness of the trunk of the maxillary artery on the cranio-caudal axis and on the latero-medial axis;

4) Distance from the maxillary artery to the crest of the articular eminence of the temporal bone;

5) Distance from the beginning of the maxillary artery and the origin of its first visible branch.

Statistical treatment

Categorical variables were described in absolute and relative values (i.e. percentages) and determined by means of visual inspection. Continuous variables were measured using a digital caliper (0-150 mm, error +/- 0,02 mm, MTX®, Tools World, Guarulhos, SP, Brazil - MTX-316119), described in millimeters and reported as means and standard-deviations.

For categorical variables the Fisher`s exact test was used. For continuous outcomes, the Shapiro-Wilk normality test was used followed by the non-paired Student`s t test or by the Mann-Whitney`s U test, if normal or non-normal distribution was indicated, respectively. All analyzes were performed on GraphPad Prism 6.01 (GraphPad, San Diego, California, United States of America), considering a 5% (0.05) significance level and a 95% confidence interval.

Results

Syntopy between the maxillary artery and the inferior alveolar and lingual nerves

The MA was located laterally to the IAN in 94,11% (16/17) of cases on the right side and on 100% (17/17) of cases on the left side. The MA was located medially to the IAN in 5,88% (1/17) on the right side and in zero cases (0%, 0/17) on the left side. There was no statistically significant difference between antimeres and with regards to the topographical situation (p>0.05, in both comparisons).

The MA was always located laterally to the LN (100% of cases, 13/13) in both antimeres, with no occurrences of the MA located medially to the LN (0%, 0/13). There was no statistically significant difference between antimeres and with regards to the topographical situation (p>0.05, in both comparisons).

Table I summarizes these findings. Figure 1 shows the different syntopies between the MA and the inferior alveolar and lingual nerves.

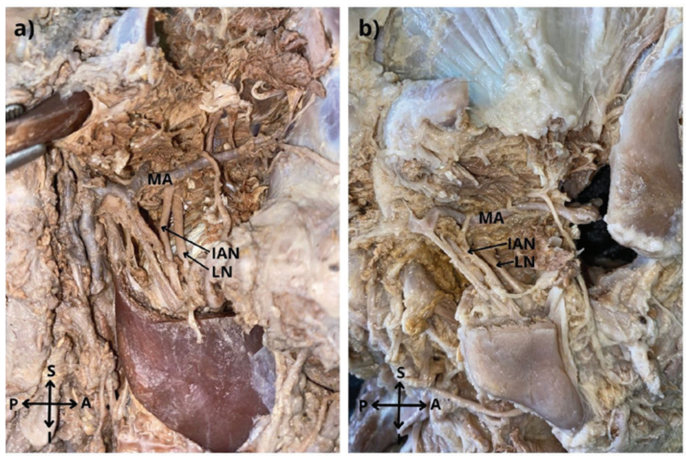

Figure 1. Lateral view of the infratemporal fossa showing: a) maxillary artery (MA) located laterally to the inferior alveolar (IAN) and lingual (LN) nerves; b) maxillary artery (MA) located medially to the inferior alveolar nerve (IAN) and laterally to the lingual nerve (LN).

Table 1. Occurrence of different syntopies between the maxillary artery and the inferior alveolar and lingual nerves.

	Inferior alveolar nerve (N = 17)				p-valor	Lingual nerve (N = 13)				p-value
	Right Side		Left Side			Right Side		Left Side		
	N	%	N	%		N	%	N	%	
Lateral	16	94,11%	17	100%	p>0.05	13	100%	13	100%	p>0.05
Medial	1	5,88%	0	0%	p>0.05	0	0%	0	0%	p>0.05
p-value	p>0.05		p>0.05		___	p>0.05		p>0.05		___

Syntopy between the MA and the lateral pterygoid muscle

The MA was located superficially to the lateral pterygoid muscle in 83,33% (15/18) of cases on the right side and on 88,23% (15/17) observations on the left side. The MA was located deeply to the lateral pterygoid muscle in 16,66% occurrences (3/18) on the right side and in 11,76% of cases (2/17) on the left side. There was no statistically significant difference between antimeres and with regards to the topographical situation (p>0.05, in both comparisons).

These results and the representations of the different syntopies between the MA and the lateral pterygoid muscle can be found, respectively, on Table II and Figure 2.

Table 2. Occurrence of different course of the maxillary in relation to the lateral pterygoid muscle.

	Right side (N = 18)		Left side (N = 17)		p-value
	N	%	N	%	
Superficial Course	15	83,33%	15	88,23%	p>0.05
Deep Course	3	16,66%	2	11,76%	p>0.05
p-value	p>0.05		p>0.05		___

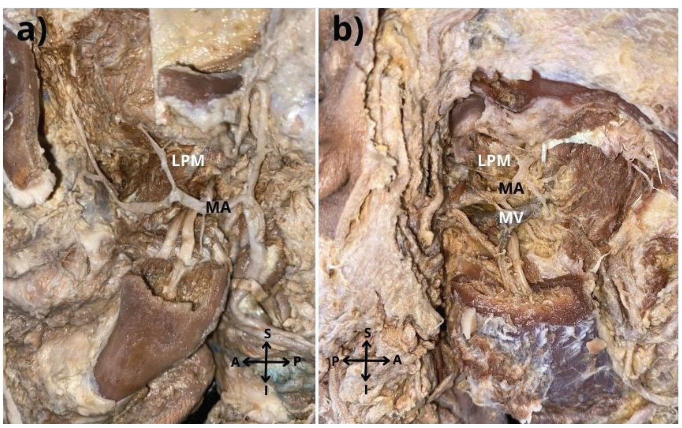

Figure 2. Lateral view of the infratemporal fossa showing: a) maxillary artery (MA) located superficially to the lateral pterygoid muscle (LPM); b) maxillary artery (MA) located deeply to the lateral pterygoid muscle (LPM). MV = maxillary vein. One can see that the deep variation can be established by noticing that the sphenopalatine artery is not identified by accompanying the course of the visible portion of the maxillary artery.

Thickness of the trunk of the maxillary artery on the cranio-caudal axis and on the latero-medial axis

On the cranio-caudal axis, the MA showed mean thickness of 2,23 mm (+/- 0,48 mm) on the right side and of 2,37 mm (+/- 0,65 mm) on the left side. Regarding the latero-medial axis, the MA showed mean thickness of 1,76 mm (+/- 0,39 mm) on the right side and of 1,72 mm (+/- 0,49 mm) on the left side. There was no statistically significant difference when antimeres were compared (p>0.05) (Table III, Figure 3b).

Distance from the maxillary artery to the crest of the articular eminence of the temporal bone and to the origin of its first visible branch

The mean distance of the MA to the crest of the articular eminence of the temporal bone was of 27,38 mm (+/- 4,39 mm) on the right side and of 26,84 mm (+/- 4,46 mm) on the left side. There was no statistically significant difference between antimeres (p>0.05) (Table III, Figure 3a).

The mean distance of the initial portion of the MA to the origin of its first visible branch, which indicates the length of its trunk (i.e. its non-divided portion), was of 11,78 mm (+/- 5,79 mm) on the right side and of 8,44 mm (+/- 5,99 mm) on the left side. When antimeres were compared, there was a statistically significant difference (p=0.029) (Table III, Figure 3b).

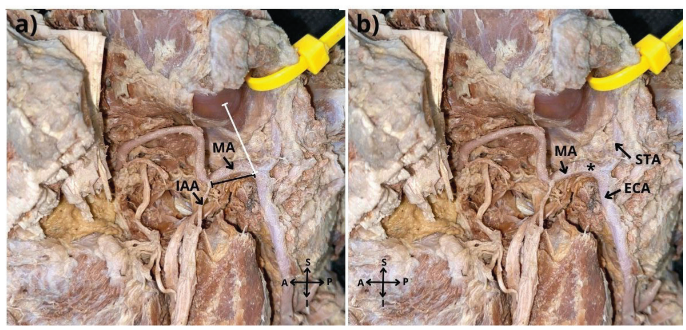

Figure 3. Lateral view of the infratemporal fossa. a) MA = maxillary artery; IAA = inferior alveolar artery; black line = distance from the maxillary artery to its first visible branch; white line = distance from the maxillary artery to the crest of the articular eminence of the temporal bone; b) a) MA = maxillary artery; ECA = external carotid artery; STA = superficial temporal artery; * = indicates the region where the trunk of the maxillary artery was measured on the cranio-caudal and latero-medial axes.

Table 3. Morphometric data regarding the trunk of the maxillary artery and distances to anatomical landmarks. MA-CAE = distance between the maxillary artery and the crest of the articular eminence; MA-OFB = distance between the maxillary artery and the origin of its first branch; mm = millimeter; SD = standard-deviation.

	Trunk thickness				Distances			
	Cranio-caudal axis		Latero-medial axis		MA-CAE		MA-OFB	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Right side	2,23 mm	+/- 0,48 mm	1,76 mm	+/- 0,39 mm	27,38 mm	+/- 4,39 mm	11,78 mm	+/- 5,79 mm
Left side	2,37 mm	+/- 0,65 mm	1,72 mm	+/- 0,49 mm	26,84 mm	+/- 4,46 mm	8,44 mm	+/- 5,99 mm
p-value	(p>0.05)		(p>0.05)		(p>0.05)		(p=0.029)	

Discussion

Thirty-five hemifaces were analyzed to establish the syntopy between the maxillary artery, the inferior alveolar nerve, the lingual nerve, and the lateral pterygoid muscle; in addition, morphometric data were collected.

In all cases on the left side and on the majority of cases on the right side, the MA was located laterally to the IAN, which show a pattern of syntopy regarding these structures. It is noteworthy that the non-significant results indicate symmetry between antimeres. In one case on the right side the MA was located medially to the IAN, which, on this specific situation, leaves it more exposed on surgeries of the infratemporal fossa from a lateral approach; on the other hand, it protects the IAN on direct nerve blocks and on the Gow-Gates technique, but it leaves the MA more exposed.[9,10] Regarding the LN, the MA was located laterally in all cases on both antimeres. Isolan & Al-Mefty (2008)[11] dissected eight human heads and found the MA located laterally to the LN and to the IAN in all cases. Hence, these findings corroborate with our study, with the exception that no case of the medial syntopy between the MA and the IAN was reported, which might be attributed to the low sample size in the aforementioned study.

The course of the MA superficially to the lateral pterygoid muscle (right side = 83,33%; left side = 88,23%) indicates that the artery is closer to the structures of the medial aspect of the mandibular ramus, hence, more exposed on procedures performed on the infratemporal fossa from a lateral approach. Our findings are similar to the description of Testut & Latarjet (1984)[12], who reported an occurrence of the superficial course of the MA on 65% of cases on an European population. According to the same authors, from an anthropological point of view, this could be explained because superior species than the primates had a widening of the distance between the neck of the mandible and the pterygomaxillary groove in detriment of a reduction of the face, hence, the MA tend to course on the shortest possible course, which is superficially to the lateral pterygoid muscle.[12] The non-significant results on comparison between antimeres suggest symmetry between sides, as well as non-significant results on the comparisons between different syntopies (superficial or deep variations) suggest a non-predictable course of the MA in relation to the lateral pterygoid muscle, despite a considerable occurrence on both sides.

Regarding morphometrical data, the thickness of the trunk of the MA on the cranio-caudal and latero-medial axes, and the distance between the MA and the crest of the articular eminence showed non-significant results ($p>0.05$) on comparison between antimeres, which also indicate symmetry. Nevertheless, the distance between the MA and the origin of its first branch (right side = 11,78 mm +/- 5,79; left side = 8,44 mm +/- 5,99), which represents the length of the trunk of the MA, presented significant results on comparison between antimeres, which might be attributed to the variability of which first branch was dissected, which by its turn is related to the quality of specimens that were previously dissected.

To best of our knowledge, there is no data on the morphometry of the MA following the same parameters of the present study, which can be considered as a strength of the proposed methodology and shows a need for new research the explore this topic. In addition, the provided morphological and morphometric data may be of use for healthcare professionals who perform clinical and/or surgical procedures on the infratemporal fossa. However, the sampling by convenience and low sample size can be considered as a limitation of our methodology. Another limitation was the use of previously dissected specimens. We suggest that authors, if possible, perform sample size calculation in order to allow a better inference of data in future research and dissect the infratemporal fossa and structures of interest, not using previously dissected specimens in order to allow a standardization of dissection procedures.

Conclusion

Within the methodological proposal of this study, we conclude the following:

The MA was predominantly found laterally to the inferior alveolar and lingual nerves;

The MA coursed superficially to the lateral pterygoid muscle on the majority of cases;

New morphometric data were provided regarding the trunk of the MA and its distance to anatomical landmarks.

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Figure 10. Human sections being used in practical classes in an undergraduate course.