



# Proximity of the maxillary artery to the neck of the mandibular condyle: anatomical study

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## Abstract

**Purpose** The objective of this study was to evaluate the anatomical distance of the maxillary artery, the most superior portion of the condyle and subcondyle in standardized coronal sections, acquired from 16 hemifaces in 8 cadavers.

**Methods** Measurements were taken to evaluate the distance between the uppermost portion of the mandibular condyle and the height of the maxillary artery (AB) and between the lateral (CD) and medial (EF) sides of the condylar neck to the artery.

**Results** The mean for AB was 21.1 mm hemiface right and 22.9 mm left on the anterior face, 22.5 mm and 20.7 mm, respectively, on the rear face. The CD measurement presented 6.7 mm right side in the anterior face and 6.3 mm left, and the posterior face was 6.3 mm right side and 5.4 mm left; EF presented a mean of 2.2 mm right and 1.5 mm left on the anterior face and 1.6 mm for both sides on the posterior face.

**Conclusions** There was no statistically significant difference between hemifaces. The proximity of the maxillary artery to the medial face of the neck of the mandibular condyle is millimetric and presents risks of severe hemorrhage for interventions in the infratemporal fossa.

**Keywords** Carotid arteries · Hemorrhage · Maxillary artery · Mandibular condyle · Temporomandibular joint

## Introduction

The internal maxillary artery (IMA) is one of the terminal branches of the external carotid artery. Its branches supply the deep structures of the face, including the maxilla, mandible, and nasal cavity [1]. This artery has high blood flow and may be responsible for mass hemorrhage with a loss of blood of up to 3 L [2] and also the formation of pseudoaneurysms in maxillofacial surgery [3], when ruptured. The anatomy of the

first and second portions (the mandible and pterygoid, respectively) is complicated due to the difficulty of access and the impractical nature of vascular ligation [4].

The proximity of the IMA and its branches to the medial surface of the temporomandibular joint (TMJ) heightens the risk of complications from surgical [5] procedures involving the infratemporal fossa. In view of this, the surgeon is required to exercise due care, preserving the adjacent structures, thereby preventing serious complications [6].

The three main surgical procedures that can lead to complications are arthroscopic surgery, open arthroplasty, and total joint reconstruction [6]. To this list of procedures may be added osteotomy of the sagittal and ascending mandibular branches, ankylosis of the temporomandibular joint, mandibular nerve block techniques, and perforation of the artery during functionally stable fixation for subcondylar fractures [7, 8].

An understanding of TMJ anatomy is required to prevent potential complications. The aim of this study was to evaluate the anatomical distance by way of coronal sections performed on cadavers, between the maxillary artery and the medial surface of the mandibular condyle, and to use this way as a parameter to avoid complications.

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## Materials and methods

For the collection of the samples, firstly, the undissected heads from 8 male cadavers were selected, aged between 30 and 40 years, preserved in 10% formaldehyde solution and frozen at a temperature of  $-20^{\circ}\text{C}$ . Sagittal sections were then performed to obtain 16 face sides.

Following sagittal sectioning to separate the face sides, a straight line was drawn parallel to the Frankfurt horizontal plane, with an interval of 2 mm between the points, for the acquisition of the coronal sections with involvement of the entire mandibular condylar region and maxillary artery (Fig. 1). A total of 5 coronal cuts were made on each side of the face (Fig. 2) using a 0.5-mm-thick band saw (Ronemak, Boituva, Brazil). Only samples of number 3 exhibited the maxillary artery and neck of the mandibular condyle on the same surface.

The dimensions used to measure the distances were quantified using digital calipers (Mitutoyo, São Paulo, Brazil) via the following points: distance between the uppermost portion of the mandibular condyle and the level of the maxillary artery (AB); distance between the lateral surface of the condylar neck and the vessel's tunica externa (CD); distance between the medial surface of the condylar neck and the vessel's tunica externa (ED) (Fig. 3), and media between AB and CD distances. Due to the thickness of the sections (2 mm), the anterior and posterior surfaces of the sample were evaluated (Fig. 4).

After verifying the normality assumptions, it was observed that the data do not present normal distribution; we chose the Wilcoxon nonparametric test whose measures of paired sample groups were compared. The descriptive measures for this test were first quartile (Q25) and median and third quartile



Fig. 2 Two-millimeter spaces between sections

(Q75), obtained in the SPSS software (Statistical Package for the Social Sciences), version 20.0.

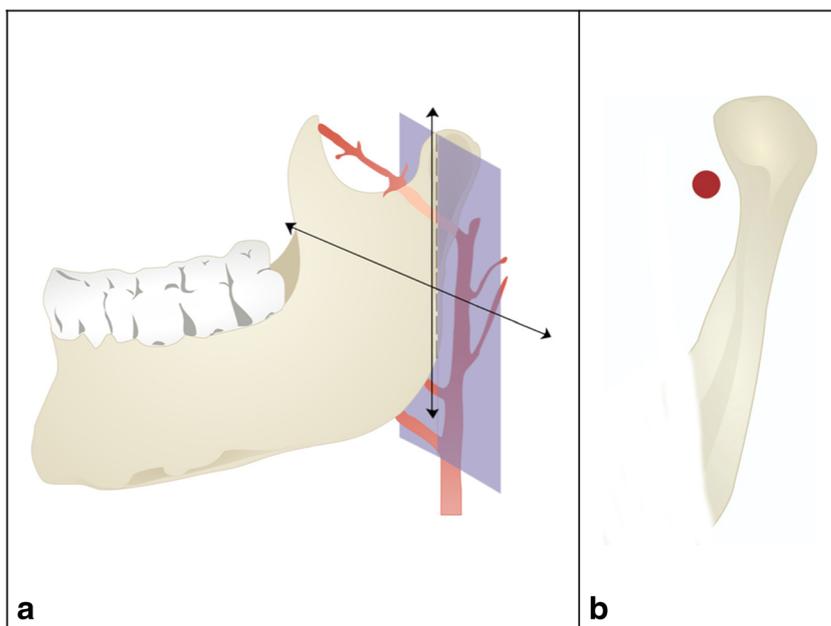
## Results

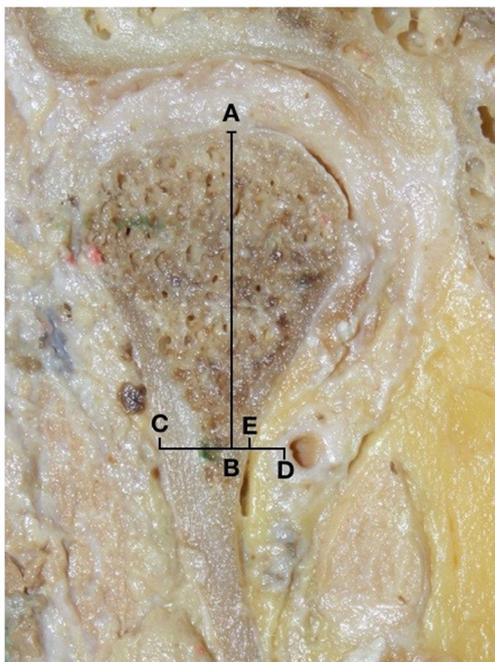
The values obtained, for the distance from the maxillary artery to the neck of the mandibular condyle, are described in Table 1.

AB distance (evaluating the ratio between the uppermost portion of the mandibular head and the level of the IMA in comparison with the condylar neck) had results of 21.1 mm for the right condyle and 22.9 mm for the left condyle (anterior surface), 22.5 mm and 20.7 mm, respectively, posterior surface.

CD distance, responsible for the evaluation between the lateral surface of the condyle neck and the vessel's tunica

Fig. 1 **a** Coronal section with involvement of the maxillary artery and mandibular condyle. **b** Frontal view of the relationship between the maxillary artery and mandibular condyle

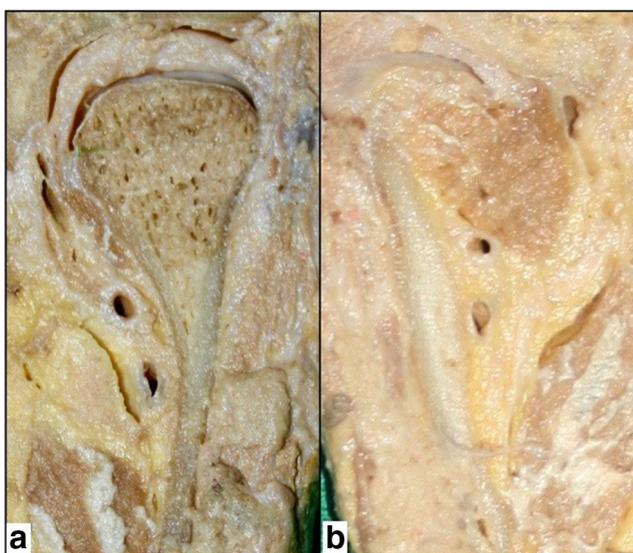




**Fig. 3** Anatomical points for distance evaluation

externa, exhibited a mean distance of 6.7 mm on the right side of the anterior surface versus 6.3 mm on the left side. The posterior surface of the section produced results of 6.3 mm on the right side and 5.4 mm on the left.

For ED distance, which measures the space between the medial surface of the condyle neck and the tunica externa of the vessel, the mean distance is 2.2 mm on the right-side face and 1.5 mm on the left-side face in the anterior section and 1.6 mm on both sides in the posterior section.



**Fig. 4** Anatomic section evidencing the proximity of the maxillary artery to the neck of the condyle. Front view (a) and posterior view (b)

When evaluating the mean between the AB and CD distances, it is possible to observe that the AB distance is on average 3.5 times greater than the CD distance according to Table 2.

For the inferential analysis, a comparison was made of each measurement obtained per face side. No statistically significant difference was observed between the right- and left-side face measurements ( $P > 0.05$ ).

## Discussion

The IMA is the largest terminal branch of the external carotid artery. Due to its deep anatomical location in relation to the face, hemorrhagic lesions can be difficult to control [9]. A tamponade through pressure and topical hemostatic agents may not be sufficient to halt bleeding due to the depth of the artery [10]. Ligature of the carotid artery may be considered as an extreme surgical option. Furthermore, endovascular embolization has been reported as another means to prevent rupture [11].

For Yeo et al. [12], ligature of the maxillary artery is the preferred hemostatic method, although technically difficult as the preauricular incision provides limited access to the vessel. Although Stephenson et al. [11] consider the ligature of the carotid artery as a surgical option, Orbay et al. [13] believe this to be controversial since, according to Takeuchi et al. [14], there is an extensive network of collateral anastomoses with the contralateral branches of the external carotid artery, the ipsilateral internal carotid artery through the ophthalmic artery, ipsilateral subclavian artery through the costocervical and thyrocervical trunks, and the ipsilateral vertebral artery where, according to Rosenberg et al. [15], the unilateral ligature of the external carotid artery, below the lingual and facial arteries, leads to a partial reduction of 40% blood flow in the maxillary artery.

Condyle fractures are one of the main causes of IMA injury [16]. The possible etiologies of this hemorrhage may result from vascular lesion caused by direct trauma or during surgical treatment resulting from the displacement of fracture fragments [10]. Arterial trauma has been reduced through the use of plates on the external cortical wall of the condyle for fixation, unlike with the use of steel wire for the fixation, given that, in these cases, it is necessary to perform bicortical fixation.

As for lesions involving the TMJ, such as ankyloses, hyperplasia, and tumors, the pattern of ossification and fibrosis of the pericapsular tissue differs greatly from patient to patient, which makes it more difficult to predict the course of the IMA due to anatomical variations and access restrictions, increasing the chance of injury [17].

For the treatment of condylar hyperplasia and other associated pathologies, Villanueva-Alcojol et al. [18] report that the most common procedure is condylectomy carried out using saws and burs through the preauricular or endaural access, which contributes to providing a better view of the condyle and the condylar

**Table 1** Values of the median (Q25–Q75) of the distance from the maxillary artery to the head of the mandible, lateral and medial surface of the condylar neck to the maxillary artery (in mm) compared with the face side (right and left) (Wilcoxon test with  $\alpha = 0.05$ ).

| Measurements                      | Distance between anatomical points |                          | P value |
|-----------------------------------|------------------------------------|--------------------------|---------|
|                                   | Face side                          |                          |         |
|                                   | Right<br>Median (Q25–Q75)          | Left<br>Median (Q25–Q75) |         |
| AB (vertical)—anterior surface    | 21.1 (20.0–25.3)                   | 22.9 (18.3–23.2)         | 0.285   |
| AB (vertical)—posterior surface   | 22.5 (19.7–25.5)                   | 20.7 (18.2–23.2)         | 0.080   |
| CD (horizontal)—anterior surface  | 6.7 (4.4–7.4)                      | 6.3 (5.9–7.8)            | 0.715   |
| CD (horizontal)—posterior surface | 6.3 (4.9–8.3)                      | 5.4 (3.6–8.3)            | 0.144   |
| ED (horizontal)—anterior surface  | 2.2 (1.5–3.0)                      | 1.5 (1.2–2.1)            | 0.078   |
| ED (horizontal)—posterior surface | 1.6 (1.1–2.7)                      | 1.6 (1.1–2.2)            | 0.223   |

neck. Osteotomy is one of the more complex stages of the surgical procedure since, according to Hoffman and Puig [19], damage to the neighboring vascular structures, such as the maxillary artery, produces considerable hemorrhaging.

In the search for strategies to minimize the risk of laceration during the osteotomy of the condyle using burs, saws, and chisels, Labanca et al. [20] used ultrasound systems for cavitation as this does not cause injury to soft tissue. In a systematic review conducted by Silva et al. [21], ultrasound systems mean an increase in the length of surgery when compared with the use of saws and are also more costly than with mechanical osteotomes [22].

In order to reduce the cost of the surgical procedure and provide improved safety for the surgeon when using mechanical osteotomes, this study shows the anatomical distance from the IMA to the neck of the mandibular condyle and also anatomical markers that facilitate the direction of the section.

In the anatomical study conducted by Orbay et al. [13] through the dissection of tissue in the maxillary artery, the authors obtained a mean distance of 22.4 mm (21.66–23.99) for the corresponding space between the maxillary artery and the condyle apex, confirming the findings of the present study. As it was not possible to assess the distance between the medial portion of the condylar neck and the IMA, Orbay et al. [13] measured the distance from the artery to the sigmoid notch, with a resulting mean distance of 5.1 mm (4.97–5.95), greater than the distance found in the present study between the medial surface of the condylar neck and the

IMA, varying from 1.1 to 3.0 mm, which increases the risk of vascular injury.

For the ratio between the AB and CD distances, it can be observed that, on average, the AB distance is 3.5 times greater than the CD, helping the surgeon to recognize the distance from the lateral cortex of the condylar neck to the artery, serving as another means of safety.

In a study carried out by Alvernia et al. [23], in which they anatomically evaluated the IMA and its variations, the authors cite angiotomography with 3D reconstruction for a better view of the course of the maxillary artery. As yet, no randomized clinical trials or trials on cadavers have been found that evaluated the distance from the IMA to the medial surface of the condylar neck, using angiotomography with 3D reconstruction.

The coronal sections carried out on both face sides, which exhibit both the mandibular condyle and the IMA, succeed in emphasizing the distance from the artery, both vertically and horizontally, in relation to the neck of the condyle, with the aim of preventing injury to the artery on account of the difficulty in viewing the structures of the infratemporal fossa.

Accordingly, distances that varied between 18.2 and 25.3 mm were found in both face sides for the level of the IMA in relation to the uppermost portion of the mandibular condyle, serving as an anatomical reference for the possible localization of the artery and position of the osteotomy.

As for the depth of the osteotomy, the anatomical measurement of the thickness of the condylar neck, through the use of computed tomography, added to the variable distance of

**Table 2** Values of the mean of the distance AB/CD (in mm) compared with the anterior and posterior surface (right and left)

| Measurements            | Mean proportion between anatomical planes |                                   |
|-------------------------|---|-----------------------------------|
|                         | Face side                                 |                                   |
|                         | Right<br>Mean (standard deviation)        | Left<br>Mean (standard deviation) |
| AB/CD—anterior surface  | 3.97 (0.6)                                | 3.6 (0.29)                        |
| AB/CD—posterior surface | 3.6 (0.6)                                 | 3.96 (1.1)                        |

between 1.1 and 3.0 mm relating to the space between the medial surface of the condylar neck and the IMA, provides greater safety for the surgeon than when the distance between the condylar neck and the aforementioned artery is unknown, minimizing the risk of complications.

Because of the low availability of cadavers in good condition, the present study had limitations in finding female individuals, which correspond to a majority of patients submitted to TMJ surgeries; this situation also limited the studies of sexual dimorphism. Another restriction in the sample is related to the age range, with a range between 30 and 40 years. Among the aspects that should be considered in future studies in humans, they include the analysis of the distances between the structures by means of angiotomographies to control a possible variation that the cadavers can present, as well as the comparison in individuals of different sexes and greater variation of age.

The knowledge of the anatomy of the maxillary artery and its relationship with the mandibular condyle is of great importance to avoid hemorrhagic problems in the treatment of the lesions involving the infratemporal fossa. The expected distance from this vessel to the condylar neck offers another method of safety to the surgeon, reducing the risk of complications.

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### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** Not required.

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