RESEARCH ARTICLE
DOI: 10.26650/Tr-ENT.2023.1241279
The Turkish Journal of Ear Nose and Throat 2023;33(1):6-10

Evaluation of the Relationship Between Mandibular Condyle and Related Arterial Structures by Computed Tomographic Angiography

Mehmet Barburoğlu[1], Yusuf Emes[2], Halim İşsever[3], Aykut Öğreden[2], Buket Aybar[2], Serra Sencer Nebiye[1]

[1]Istanbul University, Istanbul Faculty of Medicine, Department of Radiology, Istanbul, Turkiye
[2]Istanbul University, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery, Istanbul, Turkiye
[3]Istanbul University, Istanbul Faculty of Medicine, Department of Public Health, Istanbul, Turkiye

ORCID ID: M.B. 0000-0002-8715-1893; Y.E. 0000-0003-1759-6683; H.İ. 0000-0002-5435-706X; A.Ö. 0000-0001-5764-9001; B.A. 0000-0002-8819-457X; S.S.N. 0000-0002-3942-093X

Citation: Barburoglu M, Emes Y, Issever H, Ogreden A, Aybar B, Sencer Nebiye S. Evaluation of the relationship between mandibular condyle and related arterial structures by computed tomographic angiography. Tr-ENT 2023;33(1):6-10. https://doi.org/10.26650/Tr-ENT.2023.1241279

ABSTRACT

Objective: Iatrogenic injuries of internal maxillary artery (IMA) and external carotid artery (ECA) during temporomandibular and retromandibular region surgeries are serious surgical complications with high mortality and morbidity. In order to avoid this complication, it is important for surgeons to know these vascular structures' course and their relationship with the mandibular condyle and ramus. The aim of this study was to reveal the relationship of the IMA and ECA with the mandible by head and neck computed tomography (CT) angiography.

Materials and methods: Bilateral head and neck CT angiography data in 26 patients (52 region) were evaluated retrospectively. The spatial distance of IMA and ECA to the mandible was calculated in all three planes (IMAx, ECAx, IMAy, ECAy, IMAz, ECAz planes). The presence of vascular tortuosity and contact were also evaluated.

Results: We have found that the nearest distance to the ramus of the ECA before giving a branch to IMA was 32.5±7.7 mm above the line drawn tangent to the lower border of corpus mandible. The internal maxillary artery was measured to be in contact with the medial cortical surface of the mandibular condyle in 39 of the 52 angiographies. This contact point was found to be 1.74 mm in front of the posterior margin of the ramus.

Conclusion: In this study, we radiologically confirmed that the internal maxillary artery is in close association with the mandibular condyle. It is important for surgeons to be aware of this neighborhood in order to prevent intraoperative vascular injuries.

Keywords: Internal maxillary artery, external carotid artery, temporomandibular joint surgery, computed tomography angiography

INTRODUCTION

Even though major bleeding is not very common in temporomandibular joint surgery (TMJ), it is a serious complication that can be life-threatening when it occurs. Along with the external ear and facial nerve, the superficial temporal artery and internal maxillary artery are among the structures that can be injured during TMJ surgery (1). Sidebottom et al. stated that intraoperative bleeding during a total joint replacement operation was an uncommon but serious condition in only two of the one hundred cases which they included in their study (2). In these two cases, the bleeding was due to hemorrhage from a maxillary artery which was trapped inside the ankylotic tissue (2). Major intraoperative hemorrhages require the surgeon to immediately deal with this situation, which can sometimes require the external carotid artery (ECA) to be ligated or involve vessels being selectively embolized (3).

The internal maxillary artery (IMA), an important vascular structure that can be injured during TMJ and ramus surgery, leaves the ECA behind the ramus of the mandible before

Corresponding Author: Mehmet Barburoğlu **E-mail:** barburmehmet@gmail.com
Submitted: 23.01.2023 • **Accepted:** 08.02.2023 • **Published Online:** 28.03.2023

entering the infratemporal fossa (4). The aim of this study was to evaluate the relationship of the internal maxillary artery and its originating point from the ECA with the mandibular condyle and ramus on Computed Tomography Angiography (CTA) images.

MATERIAL AND METHOD

This study was approved by the ethics committee of Istanbul University, Istanbul Faculty of Medicine (Date: 02.10.2022, no: 24). Written consent was obtained from all the patients regarding the usage of their CTA images. We measured data from the CTA images of 26 patients, aged 21 to 82, who were referred to the Istanbul Faculty of Medicine Department of Neuroradiology. The data were collected retrospectively from patients who were suspected for vascular diseases of the neck. Imaging was performed on a Toshiba 64 Aquilion computed tomography (CT) scanner (Toshiba Medical Systems, Nasu, Japan) with injecting contrast material at the arterial stage. The reformatted images were evaluated retrospectively on a Toshiba CT workstation. To put a mark on axial CTA images for measuring the distance between the point where the internal maxillary artery (IMA) gets closest to the medial aspect of the mandibular condyle and the lower margin of the mandible, on coronal and sagittal reformatted images, the position of the maxillary artery in relation to the mandibular condyle was measured. We used the center tool on CTA images for marking the reference point (Figure 1).

Figure 1: In the axial computed tomography angiograph image, the arrow shows the small red circle which marks the artery's nearest point to the surface of the condyle (in contact with the posterior surface of the mandibular condyle).

ECAx: The distance between the originating point of the IMA where it departs from the ECA and the imaginary line drawn tangent to the lower margin of the mandibular body (Figure 2-A).

IMAx: The distance between the point where the IMA gets closest to the medial aspect of the mandibular condyle and the lower margin of the mandible. If IMA was located posterior to the posterior margin of the condyle, this measurement was recorded as the distance between IMA and the imaginary line drawn tangent to the lower margin of the mandibular body (Figure 2-A).

ECAy: The distance between the originating point of the IMA where it departs from the ECA and the posterior margin of the condyle. When this originating point was found to be posterior to the posterior margin of the condyle, the measurement was recorded as minus (-) (Figure 2-B).

IMAy: The distance between the point where the IMA gets closest to the medial aspect of the mandibular condyle and the posterior margin of the condyle (Figure 2-C).

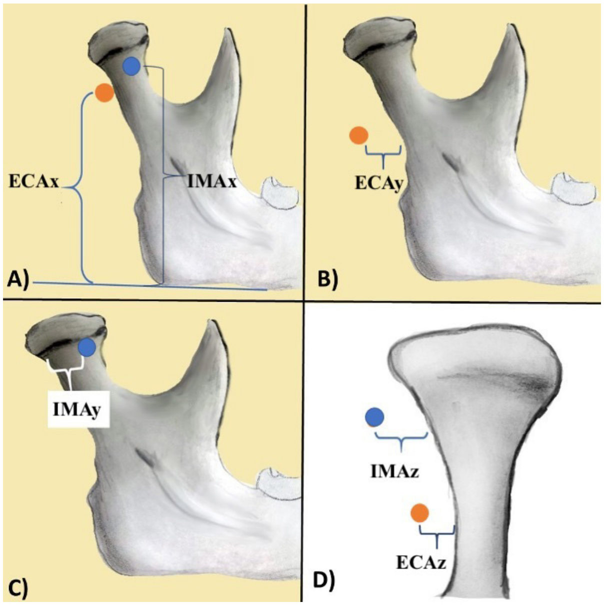

Figure 2: In the sagittal (A, B, C) and coronal (D) planes illustrations, the orange points mark the originating point of the internal maxillary artery (IMA) where it departs from the ECA and the blue points mark the point where the IMA gets closest to the medial aspect of the mandibular condyle. A) ECAx (the distance between the orange point and the imaginary line drawn tangent to the lower margin of mandibular body) and IMAx (the distance between the blue point and the lower margin of the mandible) measurements. B) ECAy (the distance between the orange point and the posterior margin of the condyle. When this originating point was found to be posterior to the posterior margin of the condyle, the measurement was recorded as minus (-)) measurement. C) IMAy (the distance between the blue point and the posterior margin of the condyle) measurement. D) IMAz (the distance between the blue point and the medial aspect of the mandibular condyle) and ECAz (the distance between the orange point and medial aspect of the mandibular condyle. When the ECAy was a minus value, ECAz was not measured) measurements.

ECAz: The distance between the originating point of the IMA where it departs from the ECA and medial aspect of the mandibular condyle. When the ECAy was a minus value, ECAz was not measured (Figure 2-D).

IMAz: The distance between the point where the IMA gets closest to the medial aspect of the mandibular condyle and the medial aspect of the mandibular condyle (Figure 2-D).

Statistical Analysis

Descriptive statistical analyses were performed for all the variables examined in this study. Compliance with the normal distribution of the data obtained by measurement was established using the Kolmogorov Smirnov and Shapiro-Wilk tests. The data obtained by measurement were expressed as mean ± standard deviation and median (min-max). The relationships between the measurement levels were given by calculating the Spearman correlation coefficient. Statistical significance was accepted as $p<0.05$ and two-tail.

RESULTS

Evaluation of the measurements have shown a statistically significant positive relationship at medium strength between the measurements ECAx and IMAx (rs=0.584; $p<0.001$) (Table 1), (Figure 3). A low negative correlation between ECAy and IMAy measurements was found to be statistically significant (rs=0.301; p=0.03).

Between the measurements IMAx and IMAy there was a statistically significant, moderately positive relation (rs=0.706; $p<0.001$), and between IMAy and IMAz, there was a weak negative relation which was statistically significant. (rs=-0.444; p=0.002) (Figure 4).

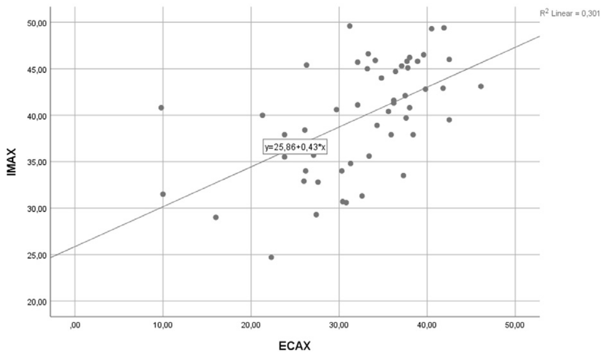

Figure 3: Relation between ECAx and IMAx

ECAx: The distance between the originating point of the IMA where it departs from the ECA and the imaginary line drawn tangent to the lower margin of mandibular body.
IMAx: The distance between the point where the IMA gets closest to the medial aspect of the mandibular condyle and the lower margin of the mandible. If IMA was located posterior to the posterior margin of the condyle, this measurement was recorded as the distance between IMA and the imaginary line drawn tangent to the lower margin of the mandibular body.

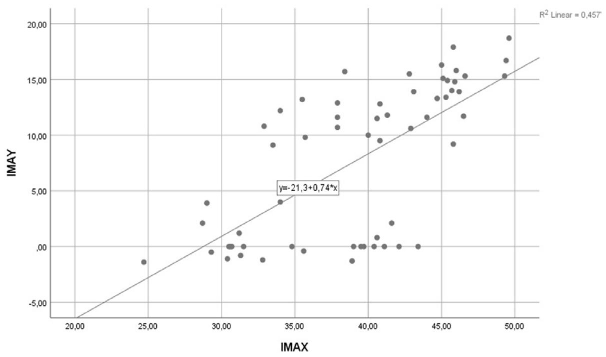

Figure 4: Relation between IMAx and IMAy

IMAx: The distance between the point where the IMA gets closest to the medial aspect of the mandibular condyle and the lower margin of the mandible. If IMA was located posterior to the posterior margin of the condyle, this measurement was recorded as the distance between IMA and the imaginary line drawn tangent to the lower margin of the mandibular body.
IMAy: The distance between the point where the IMA gets closest to the medial aspect of the mandibular condyle and the posterior margin of the condyle.

Table 1: Distribution of measurements of the joints included in the study

	ECAx	ECAy	ECAz	IMAx	IMAy	IMAz
Mean	32.51	-1.08	3.20	39.22	7.74	0.35
Std. Deviation	7.71	2.58	2.96	6.19	6.78	0.65
Median	**33.75**	**-1.55**	**3.65**	**40.40**	**10.00**	**0.00**
Minimum	9.80	-5.30	0.00	24.70	-1.40	0.00
Maximum	46.1	10.1	7.9	49.6	18.7	2.8

(ECA: external carotid artery, IMA: internal maxillary artery) ECAx: The distance between the originating point of the IMA where it departs from the ECA and the imaginary line drawn tangent to the lower margin of mandibular body. ECAy: The distance between the originating point of the IMA where it departs from the ECA and the posterior margin of the condyle. When this originating point was found to be posterior to the posterior margin of the condyle, the measurement was recorded as minus (-). ECAz: The distance between the originating point of the IMA where it departs from the ECA and medial aspect of the mandibular condyle. When the ECAy was a minus value, ECAz was not measured. IMAx: The distance between the point where the IMA gets closest to the medial aspect of the mandibular condyle and the lower margin of the mandible. If IMA was located posterior to the posterior margin of the condyle this measurement was recorded as the distance between IMA and the imaginary line drawn tangent to the lower margin of the mandibular body. IMAy: The distance between the point where the IMA gets closest to the medial aspect of the mandibular condyle and the posterior margin of the condyle. IMAz: The distance between the point where the IMA gets closest to the medial aspect of the mandibular condyle and the medial aspect of the mandibular condyle.

The relationship between IMAz and IMAx was also weakly negative and statistically significant (rs=-0.397; p=0.002). Two of the patients with bilateral tortuosity had the IMAz measurement as 0 twice on both sides, which meant that the artery had contact with the bone at two points on each side. Tortuosity was observed in four patients, three of whom had bilateral tortuosity of the maxillary artery. All of the patients with tortuosity of the maxillary artery had a distance of 0 mm in measurement z plane.

We have found that the nearest distance of the ECA before giving a branch to IMA was 32.5±7.7 mm above the line drawn tangent to the lower border of the corpus mandible. The IMA was measured to be in contact with the medial cortical surface of the mandibular condyle in 39 of the 52 angiographies. This contact point was 1.74 mm anterior to the posterior margin of the ramus. The nearest distance to the posterior margin was measured to be 0 mm (the artery makes contact with the bone on the posterior margin of the mandibular condyle), and the highest distance of the contact was measured to be 18.7 mm anterior to the posterior margin of the mandibular condyle. The average distance of this point from the lower border of the mandible was 39.7 mm. The lowest contact point between the IMA and bone was at 28.7 mm, the highest was at 49.6 mm.

DISCUSSION

The internal maxillary artery (IMA) departs from the ECA behind the ascending ramus of the mandible before entering the infratemporal fossa. It continues anteriorly, leaving the pterygopalatine fossa and the pterygomaxillary fissure behind to divide into two branches in the infratemporal fossa as the IMA enters the fossa lateral to the lateral pterygoid muscle, which consists of two parts (upper and lower) inserting into the temporomandibular joint (TMJ) (4). Surgeries involving the TMJ and mandibular condyle are prone to hemorrhages resulting from the injury of the IMA. The anatomy of the maxillary artery, which is an important route of blood supply to the soft and hard tissues of the maxillofacial region, has been an interest of research both radiographically and macroscopically (5-10).

Researchers have reported a great variety of anatomical courses for the maxillary artery and the originating point has been studied by several researchers (5). Authors have used various measurement landmarks for the origin of the maxillary artery since there is not a consensus on how to measure this anatomical structure. Takarada and Ikakura et al. used the mandibular ramus, whereas Ito et al. measured its distance to the eye-ear plane corresponding to the superficial temporal artery (11-13). Ikakura and Takarada et al. reported the origin of the maxillary artery to be as high as 2/5 to the posterior border of the mandibular ramus in most of the subjects (80%). In the present study, we have found that the nearest distance of the ECA before giving a branch to IMA was 32.5±7.7 mm above the line drawn tangent to the lower border of the body of the mandible (11, 12).

The positive relation between the values ECAx and IMAx is not surprising since it shows that the higher the maxillary artery departs from the external carotid, the higher it lies anteriorly. When we evaluate the positive relation between ECAx and IMAx, we observe that when the maxillary artery departs from the external carotid at a higher level, this may mean that it approaches the medial aspect of the condyle at a more anterior point. However, it must be kept in mind that the results of the present study show that this positive relation is weak.

Also, the positive relation between the measurements IMAx and IMAy point to a course of the maxillary artery in which the more cranially the maxillary artery is located, the more anteriorly it approaches the medial aspect of the condyle. Our findings also show that, as the maxillary artery is located the closest to the medial aspect of the condyle, there is a possibility that this point is more anterior to the posterior margin of the condyle and more cranial to the lower margin of the mandibular ramus (negative relation between IMAy and IMAz, and negative relation between IMAx and IMAz respectively).

Otake et al. have reported that the maxillary artery runs lateral to the external pterygoid muscle in 94.6% of their specimens (5). Even though we have not evaluated the relationship between the pterygoid muscle and the maxillary artery, our findings state that the maxillary artery can be very close to the medial aspect of the mandibular condyle. The maxillary artery was measured to be in contact with the medial cortical surface of the mandibular condyle in 39 of the 52 angiographies. However, there was no statistically significant relationship between this contact and measurements in other planes.

Our findings have shown that of the 39 angiographs in which the IMA was measured to be in contact with the medial aspect of the mandibular condyle, this contact point was 1.74 mm anterior to the posterior margin of the ramus. The nearest distance to the posterior margin was measured to be 0 mm (the artery makes contact with the bone on the posterior margin of the mandibular condyle), and the highest distance of contact was measured to be 18.7 mm anterior to the posterior margin of the mandibular condyle. These findings suggest that during any surgical procedures involving the mandibular condyle, the surgeon must be aware that the MA may be in contact with the condyle between the most posterior margin and 18.7 anterior to the posterior margin.

The average distance of this point from the lower border of the mandible was 39.7 mm. The lowest contact point between the MA and bone was at 28.7 mm and the highest was at 49.6 mm, which also must be considered by the surgeon.

Tortuosity can be observed on the course of the maxillary artery, which can make interventions to this anatomical structure difficult in infratemporal fossa surgery (14). It has been previously stated that detection of the tortuosity of the maxillary artery was crucial for the procedures for controlling epistaxis (15). We have found tortuosity in 15.38% of the patients and this was bilateral in 11 of the patients.

A drawback of the present study is the preference of anatomical points related to the mandible, which is a mobile bone, and these measurements may change according to the mandibular position. Several authors have chosen various anatomical structures as landmarks for anatomical studies in the past. Talebzadeh et al. selected stable measurement points, such as the outer aspect of the zygomatic arc and the line drawn from the uppermost point of the glenoid fossa (16). Otake et al. measured the distance between the originating point of the maxillary artery and the external auditory canal (5).

The anatomical landmarks used in the present study were selected due to their direct involvement in the temporomandibular joint surgery. Structures such as the lower border of the mandible and the mandibular condyle are visible to the surgeon in various surgical approaches, such as the preauricular approach or submandibular approach. The weaknesses of this study are the small number of patients included in the study and the fact that it was performed retrospectively on CT angiography of patients who were examined for vascular diseases.

CONCLUSION

The present study confirms that the internal maxillary artery is in close relationship with the mandibular condyle and ramus. Therefore, the risk of internal maxillary artery injury should be considered in light of this close relationship in surgical procedures involving the mandibular condyle.

Ethics Committee Approval: This study was approved by Istanbul Faculty of Medicine Clinical Research Ethics Committee (Date: 02.10.2022, no: 24).

Informed Consent: Written informed consent was obtained.

Peer Review: Externally peer-reviewed.

Author Contributions: Conception/Design of Study- M.B., Y.E., N.S.S., B.A.; Data Acquisition- M.B., Y.E., B.A., A.Ö., H.İ., N.S.S.; Data Analysis/ Interpretation- H.İ., M.B., Y.E., B.A.; Drafting Manuscript- Y.E., M.B., A.Ö., H.İ., B.A.; Critical Revision of Manuscript- Y.E., H.İ., M.B., N.S.S., B.A.; Final Approval and Accountability- M.B., Y.E., B.A., N.S.S.; Material or Technical Support- A.O., H.İ.; Supervision- B.A., N.S.S., Y.E.

Conflict of Interest: The authors have no conflict of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

REFERENCES

1. Peoples JR, Herbosa EG, Dion J. Management of internal maxillary artery hemorrhage from temporomandibular joint surgery via selective embolization. J Oral Maxillofac Surg 1988;46(11):1005-7.
2. Sidebottom AJ, Gruber E. One-year prospective outcome analysis and complications following total replacement of the temporomandibular joint with the TMJ Concepts system. Br J Oral Maxillofac Surg 2013;51(7):620-4.
3. Bouloux GF, Perciaccante VJ. Massive hemorrhage during oral and maxillofacial surgery: ligation of the external carotid artery or embolization? J Oral Maxillofac Surg 2009;67(7):1547-51.
4. Flint PW, Haughey BH, Robbins KT, Thomas JR, Niparko JK, Lund VJ, et al. Cummings otolaryngology-head and neck surgery e-book. Elsevier Health Sciences. 2014. p.2662-70.
5. Otake I, Kageyama I, Mataga I. Clinical anatomy of the maxillary artery. Okajimas Folia Anat Jpn 2011;87(4):155-64.
6. Sashi R. X-ray anatomy of the maxillary artery. Akita J Med 1989;16:817-31.
7. Tsuda K. Three Dimentional analysis of Arteriographs of the Maxillary Artery in Man-Part 1: The maxillary artery and its branches. J Jpn PRS 1991;11:188-98.
8. Tsuda K. Three Dimentional analysis of Arteriographs of the Maxillary Artery in Man-Part 2: Branching patterns of branches of the maxillary artery. J Jpn PRS 1991;11:683-90.
9. Lurje A. On the topographical anatomy of the internal maxillary artery. Acta Anat 1946;2(3-4):219-31.
10. Kitsuta H, Lin E, Kato T, Ide Y, Kaneko Y. The Procession of the N. Mandibularis, A Maxillaris and Vv.Maxillares of Japanese people during the Open-mouth Position. Shikwa gakuho 1985;85(11):1523-32.
11. Takarada T. Anatomical studies on the maxillary artery. Shikwa gakuho 1958;58:1-20.
12. Ikakura K. On the origin, course and distribution of the maxillary artery in Japanese. Arch Dept of Anat Tokyo Dent Coll. (Kouku Kaibou Kenkyu) 1961;18:91-122.
13. Ito H, Mataga I,Kageyama I, Kobayashi K. Clinical anatomy in the neck region; The position of external and internal carotid arteries may be reversed. Okajimas Folia Anat Jpn 2006;82(4):157-67.
14. Verma S, Fasil M, Murugan M, Sakkarai J. Unique variation in the course of maxillary artery in infratemporal fossa: a case report. Surg Radiol Anat 2014;36(5):507-9.
15. Metson R, Lane R. Internal maxillary artery ligation for epistaxis: an analysis of failures. Laryngoscope 1988;98(7):760-4.
16. Talebzadeh N, Rosenstein TP, Pogrel MA. Anatomy of the structures medial to the temporomandibular joint. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1999;88(6):674-8.