Vol. 12, No. 4, October - December 2020

MORPHOLOGICAL VARIATIONS AND CLINICAL IMPLICATIONS OF THE INFERIOR ALVEOLAR ARTERY

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Abstract

The inferior alveolar artery (IAA), a collateral branch of the maxillary artery, is mainly responsible for the vascularization of the mandibular tooth-gum-alveolar bone units. In its course from the infratemporal region to the body of the mandible, the IAA may exhibit variations in both origin and trajectory. This study analyses the anatomical variations of the IAA and describes potential clinical complications following different surgical procedures in the mandible. A comprehensive literature review across Clarivate Analytics/Thomson Web of Knowledge and PubMed databases was conducted. The following keywords were used: inferior alveolar artery, anatomical variations, posterior mandible, clinical consequences. Data from similar previous personal research were also added to the findings. The results of this study suggest that the posterior mandible remains the major risk area for damage to the IAA.

Key words: inferior alveolar artery, anatomical variations, posterior mandible, clinical consequences

Introduction

The inferior alveolar artery (IAA) is the main artery which supplies blood to the mandibular teeth and to the mandible. In most cases, it branches from the maxillary artery into the infratemporal fossa or it can detach itself in Juvara's retro-condylar space. The inferior alveolar vein and the inferior alveolar nerve accompany the IAA in its trajectory, forming together the inferior alveolar neurovascular bundle [1, 2]. The IAA has an anterior, inferior and lateral trajectory from its origin up to the point it reaches the pterygomandibular space,

descending between the mandible ramus and the medial pterygoid muscle. At the level of the pterygomandibular space the IAA penetrates through the mandibular foramen into the mandibular canal, where it also joins the inferior alveolar vein and the inferior alveolar nerve [1, 2].

Along its path the IAA gives off branches for different anatomical structures such as: the mylohyoid artery intended for the mylohyoid muscle; the artery to the lingual nerve that vascularizes the lingual nerve; the mental artery that supplies blood to the lower lip and to the soft parts of the chin; and arterial branches for vascularization of the pterygoid muscles. Moreover, there are also arterial vessels that detach from the IAA into the mandibular canal and that are directed to the mandibular teeth, periodontium, alveolar bone, buccal gingiva and buccal alveolar mucosa. Interestingly, some authors have shown that the IAA gives rise to a horizontal branch for the vascularization of the cheek, just before it enters through the mandibular foramen [3, 4].

Similar to the other arteries that supply the face, the IAA develops from the mesenchymal tissue of the first aortic arch that is part of the branchial system. Nevertheless, the blood vessels are different depending on the anatomical area and on the demand of the tissue they vascularize. The structure of the vessels of the vascular system is highly specialized to suit their individual functions and anatomical relationships [5].

Unlike the normal vascularization vessels, the neoformation vessels, e.g. those in tumours, have a modified or even altered morphology [6].

In dental medicine the IAA is exposed to surgical risks during mandibular osteotomies or other invasive dentoalveolar surgery procedures in the mandible.

Although the anatomical variations in the origin, trajectory and branches of the IAA presented in the literature are quite rare, these variations are important for dental clinicians as they can increase the risk of damage to the content of the mandibular canal and consequently of the IAA during surgical procedures in the mandible, especially in its posterior area [7, 8].

Materials and methods

An extensive literature review across Clarivate Analytics / ISI Thomson Web of Knowledge and PubMed databases was conducted. The following keywords were used: inferior alveolar artery, morphological variations, posterior mandible. Any type of article, review or clinical trial performed on human subjects, was included in the study.

We also added data obtained through various previous personal research and studies, to which we added the analysis of complications arising during and following dentoalveolar surgery procedures performed in the posterior mandible.

Results and discussion

The maxillary artery constantly gives rise to most of its branches, including the IAA, in the infratemporal fossa. Thus, dental clinicians should take into account the anatomy of the maxillary artery and of the IAA while performing various oral and maxillofacial surgery procedures.

The IAA is accompanied by the inferior alveolar nerve, being satellite to this nerve, in its downward trajectory in the pterygomandibular space, passing through the mandibular foramen and then further into the mandibular canal. The proximity of the IAA to the inferior alveolar nerve at the level of pterygomandibular space poses a potential risk for vascular damage during loco-regional anaesthesia of the inferior alveolar nerve at the level of the mandibular foramen.

It has been reported that the vascular damage of the IAA during anaesthesic procedures near the mandibular foramen is quite frequent, occurring in 20% of cases. Furthermore, any variation in the trajectory of the IAA may increase this potential risk of damage [9].

Variations in the origin of the IAA are quite rare, as compared to the variations in its trajectory. However, one study presented a situation in which the IAA originated directly from the external carotid artery, 3.5 cm below its terminal bifurcation, unilateral left variation in origin of the IAA. Therefore, such a variation, although rare, should be taken into account in the case of surgical interventions in the posterior mandible [2].

Jergenson MA et al., 2005, described a similar variation in origin of the IAA. According to these authors, the IAA detached from the external carotid artery, above the stylohyoid muscle and the posterior belly of the digastric muscle in the posterior area of the submandibular region, another unilateral left variation of IAA origin. From its origin, the IAA showed an ascending path and a curved trajectory in the pterygomandibular space, and then it entered the mandibular foramen. Therefore, surgical procedures like sliding osteotomies of the mandible could be affected by this variation of arterial origin, as such an arterial variation predisposes to complications [10].

Velasco I et al., 2011, presented other variations in the origin of the IAA. In one case, on the right side, the IAA emerged from the external carotid artery in the infratemporal fossa 5 mm lower from its terminal bifurcation through a common trunk with the buccal artery, the bucoalveolar trunk, but, on the left side the IAA derived from the maxillary artery and formed a common trunk with the pterygoid branches of the maxillary artery. According to these authors, knowledge of arterial morphological variations is important for inferior alveolar nerve anaesthesia and for oral and maxillofacial surgery because anatomical variation in the area can lead to a major increase in the rate of complications of these invasive procedures [11].

Quadros LS et al., 2013, showed that the inferior alveolar artery detaches from the maxillary artery in the infratemporal fossa through a common trunk with the deep posterior temporal artery, the temporoalveolar trunk, unilateral right variation in origin [12]. Other researchers also reported that the IAA detaches from the maxillary artery into the infratemporal fossa through a common trunk with the posterior deep temporal artery, the temporoalveolar trunk [13].

The morphological variations concerning the origin of the IAA may alter and complicate surgical procedures in the posterior mandible, in the infratemporal fossa or

parotidectomies. Therefore, knowledge of these morphological variations becomes important for surgeons and radiologists who interpret angiographies [14].

Brennan PA et al., 2017, stated that when these anatomical variations are present, bilateral sagittal osteotomy of the mandibular ramus may be a procedure that could damage the IAA at its entrance to the mandibular foramen. In order to avoid this type of damage, some actions should be taken so as to help reduce the risk of haemorrhage from the IAA: careful subperiostal dissection of the mandibular ramus, identification of the mandibular foramen and delicate repositioning_of the inferior alveolar neurovascular bundle during ostetomy [15].

However, no consensus has been reached in the medical literature regarding the exact relationships between the structures that make up the inferior alveolar neurovascular bundle.

Pogrel AM et al., 2009, described that the IAA is located in the mandibular canal on the lingual side of the inferior alveolar nerve and slightly above the nerve [16]. Knowledge of the arrangement of the inferior alveolar neurovascular bundle in the mandibular canal may be important in surgical procedures that may involve these structures. Dentoalveolar surgery, dental implant surgery and surgery for mandibular trauma could involve these neurovascular structures [16].

Nimigean V, 2011, stated that the IAA is placed inferior to the inferior alveolar nerve in most of the mandibular canal, passing superior to the inferior alveolar nerve only in the posterior part of the mandibular canal. Interestingly, the diameter of the IAA decreases with age, which is particularly important for microsurgical anastomoses and reducing risk of injury to the mandibular neurovascular bundle during mandibular reconstructive interventions. The relationship between the IAA and the inferior alveolar nerve in the mandibular canal is similar to the blood barrier of the brain: highly selective and impermeable. Moreover, the damage to the nerve and to its ability to recover is closely related to the degree of vascularization and implicitly to the anoxia of a given territory [17].

Bertl K et al., 2015, in a radiological study of mandibles from human cadavers, found that in the mandibular canal the IAA showed a superior (cranial) position in 42% of cases, followed by the lingual position in 36% of cases, the lower (caudal) position in 16% of cases and the buccal position in 6% of cases. Hence there are certain variations regarding the relationships between the structures that make up the inferior alveolar neurovascular bundle. These observations are important for surgery performed near the mandibular canal [18].

The decrease in the size of the IAA is most commonly due to arteriosclerosis. However, it has been suggested that narrowing of the lumen of the IAA may represent a form of involutive artery atrophy associated with tooth extraction and progressive resorption of the residual alveolar process [19].

Data for this paper were obtained from personal observations completed with rigorous research of the medical literature. The results of this study present variations and controversial situations regarding the trajectory of the mandibular canal and the

relationships between its neurovascular content in the posterior area of the mandibular body.

That being said, the anatomical variations could explain the situations in which these elements of the mandibular canal are affected. Therefore, the IAA might be damaged during some dental surgical operations especially in the posterior mandibular area where the mandibular canal has the highest position in the mandibular body.

In conclusion, such situations require a review of the regional anatomy data, the therapeutic precautions and the potential consequences of a possibly inadequate therapy [8].

In present day medical practice, implant-supported oral rehabilitation is a routine dental procedure. Hence, the frequent dental implant placement in the posterior area of the mandible increased the number of neurosensory disorders and postoperative bleeding [7, 20].

Although according to the literature data the position of the IAA is quite variable, Resnik RR and Misch CE, 2018, wrote that the IAA is normally located above the inferior alveolar nerve in the mandibular canal, especially in the posterior area of the mandible. As a result, under these circumstances the placement of an implant in the mandibular canal may predispose to significant bleeding. If bleeding occurs, postoperative care is essential, since the formation of a haematoma in the mandibular canal can lead to neurosensory impairment [21].

Therefore, it can be stated that the variations in the origin and trajectory of the IAA are rarer than those of other branches of the external carotid artery presented in other studies [22-26].

Of utmost importance is also the fact that the particular morphological patterns encountered at vascular and at bone levels may predispose to disorders or complications [27].

In order to reduce the clinical complications stemming from the morphological variations of the inferior alveolar artery, key topographic patterns need to be known: the inferior alveolar neurovascular bundle, the mandibular canal and the bone foramina that allow the passage of the trigeminal nerve at the level of the mandible [7, 8, 28, 29].

In our opinion, the existence of clinical experimental models would prove to be of increased utility as compared to the experimental animal models, the latter being far more frequently presented in the literature [30-33].

Conclusions

The posterior mandible, where the mandibular canal and its content are in the highest position, is the major risk area for dental implant therapy in the mandible.

Precise knowledge of the origin, trajectory and anatomic rapports of the IAA favours the successful completion of dentoalveolar surgery procedures and osteotomies in the posterior mandible, while also avoiding or minimizing accidents and complications.

Author contribution

Author #1 (Victoria Roxana Ivaşcu), autor #2 (Alexandru Poll), autor #3 (Maria Justina Roxana Vîrlan) and autor #4 Dan Ionuţ

Sălăvăstru have equal contributions to this paper and thus are main authors.

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