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The relationship between the auriculotemporal nerve and middle meningeal artery in a sample of the South African population

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Background: *The interaction between the auriculotemporal nerve and the middle meningeal artery within the infratemporal fossa is vital in the spread of perineural tumours. Knowledge of their morphological and morphometric variations is critical to surgeons approaching the infratemporal fossa. There is a paucity of literature on the relationship between the auriculotemporal nerve and middle meningeal artery in a South African population. Hence, the aim of this study was to document the morphology and morphometry of the auriculotemporal nerve and its relationship to the middle meningeal artery within a South African cohort.*

Materials and methods: *The infratemporal fossae of 32 cadaveric specimens were dissected and the auriculotemporal nerves and middle meningeal arteries were analysed, together with their variations.*

Results: *Nine out of 32 specimens displayed one-root, 14/32 two-root, 7/32 three-root, and 2/32 four-root auriculotemporal nerves. Eighteen auriculotemporal nerves originated from the mandibular nerve, while the rest had at least one communication to the inferior alveolar nerve. The mean distance between the first and second roots of the auriculotemporal nerve was 4.69 mm. There were V-shaped formations found in 23 auriculotemporal nerves. However, the middle meningeal artery only passed through 13/23 V-shapes. The maxillary artery was of a deep course in relation to the lateral pterygoid muscle in 19/32 and superficial in 13/32 of the sample. There were 15 accessory middle meningeal arteries present in 14/32 specimens. The accessory middle meningeal arteries often arose from the middle meningeal artery (46.67%).*

Conclusions: *The results of this study show a high possibility of variations of the auriculotemporal nerve and middle meningeal artery in the South African population. The variations and interactions should be considered during surgical procedures.* (Folia Morphol 2024; 83, 1: 66–71)

Keywords: infratemporal fossa, mandibular nerve, maxillary artery, meningeal arteries, neoplasms

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INTRODUCTION

The auriculotemporal nerve (ATN) may be involved in parotid gland cancers and the resultant perineural tumour spread along the nerve may extend cranially to the foramen ovale, through which the mandibular branch of the trigeminal nerve passes [5, 19]. The progression of a tumour along the ATN can compromise tissues in the infratemporal fossa, cause trigeminal nerve palsy, and displace or obliterate vascular structures [17, 21]. The interaction between nerves and vessels is critical in the spread of perineural tumours, and the close association between the ATN and the middle meningeal artery [22] may cause additional complications [17]. As a result, medical practitioners must understand the morphology of the ATN and its relationship to the middle meningeal artery (MMA), as well as the anatomy of the infratemporal fossa, to appropriately identify the neurovasculature and limit the risk of complications during procedures to the infratemporal fossa. However, the relationship between the ATN and MMA has not been investigated in a South African population.

The auriculotemporal, inferior alveolar, and lingual nerves are the cutaneous branches of the posterior division of the mandibular nerve [8, 18]. The ATN has been reported to arise as two roots within the infratemporal fossa, forming a buttonhole to encircle the MMA before re-joining to form its main trunk [8, 18]. Some aural structures, the temporomandibular joint, the posterior portion of the temple, and the parotid gland, are innervated by the ATN [8, 10, 18].

The MMA is the maxillary artery's largest branch, and originates within the infratemporal fossa as the third branch from the first segment of the maxillary artery [11, 18]. The MMA coursed cranially through the buttonhole of the ATN and entered the cranium via foramen spinosum, supplying the dura mater [11, 18]. The infratemporal fossa may contain an accessory MMA, which arises from either the MMA or the maxillary artery, depending on the anatomical relationship between the maxillary artery and the lateral pterygoid muscle [1, 4, 11, 18].

While standard anatomical text stipulates the usual morphology of the ATN and its relationship to the MMA, many authors have discovered variations in this regard [3, 5, 7, 9, 13, 20]. Hence, the present study aimed to document the morphological and morphometrical anatomy of the ATN, the relationship between the MMA and the ATN, as well as their variations (if any) in a South African sample.

MATERIALS AND METHODS

The study used 16 formalin-fixed South African cadavers dissected bilaterally (n = 32) at the Department of Clinical Anatomy, University of KwaZulu-Natal. The Biomedical Research Ethics Committee at the University of KwaZulu-Natal granted ethical permission for this study (BREC/00002919/2021). The dissection procedures followed those of Dias et al. [7], Komarnitki et al. [13], and Loukas et al. [14].

This study used all available adult cadavers with no visible injury to the mandibular ramus or contents of the infratemporal fossa. The cadavers were placed in a supine position and dissected to expose the infratemporal fossa and its contents. The skin and superficial tissue overlying the zygomatic arch, parotid gland and duct, and mandibular ramus was removed. Thereafter, the zygomatic arch and mandibular ramus was cleaned and dissected using a bone saw to expose the contents of the infratemporal fossa [13]. The lateral and medial pterygoid muscles were dissected to reveal the deep contents of the infratemporal fossa, *viz.* the mandibular nerve and the MMA. Tracing the inferior alveolar nerve superiorly to the foramen ovale assisted in identifying the trunk of the mandibular nerve [14]. The roots of the ATN were cleaned and traced from the most inferior root to facilitate proper identification of the ATN's variations. The MMA was also cleaned and traced from its origin to the foramen ovale. The maxillary artery was identified, and the part from which the MMA originated was recorded. Variations in the ATN's roots and its relationship with the MMA were documented, as well as the presence of the accessory middle meningeal artery (aMMA). The distance between the roots of the ATN was measured three times for accuracy using a digital vernier calliper. The descriptions and data were entered on a Microsoft Excel 2016 spreadsheet for analysis.

The data were statistically analysed using the R Project for Statistical Computing software (version 3.6.3 of the R Core Team). Data were analysed using descriptive statistics, and parameters were found to be statistically significant with p-values less than 0.05.

RESULTS

The results of this study is shown in Table 1.

Demographics

The specimens used in the study were of South African White (87.50%) and Black (12.50%) descent. The cadavers were of an older cohort (72.4 ± 11.9

Table 1. Quantity and description of ATN, MMA, and aMMA discovered in the bilateral dissection of infratemporal fossae in a South African population (n = 32)

One-root ATN (%)	Two-root ATN (%)	Three-root ATN (%)	Four-root ATN (%)	Buttonhole formations (%)	V-shape formations (%)	aMMA present (%)	Maxillary artery deep to LPM (%)	Maxillary artery superficial to LPM (%)
9 (28.13%)	14 (43.75%)	7 (21.88%)	2 (6.25%)	1 (3.13%)	22 (68.75%)	14 (43.75%)	19 (59.38%)	13 (40.63%)

aMMA — accessory middle meningeal artery; ATN — auriculotemporal nerve; LPM — lateral pterygoid muscle

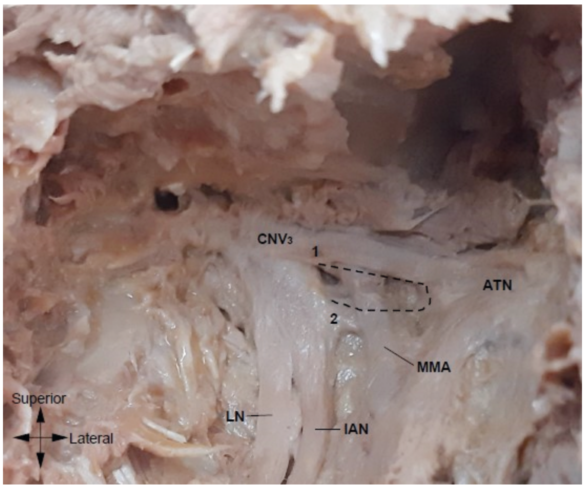

Figure 1. A two-root auriculotemporal nerve (ATN) and middle meningeal artery (MMA) within the infratemporal fossa. The first root of the nerve joins with the second root, forming a V shape (black dashed line). The MMA coursed through the V shape; 1 — first root of ATN, 2 — second root of ATN; CNV_3 — mandibular nerve; LN — lingual nerve; IAN — inferior alveolar nerve.

years) and there was equal distribution regarding the sex of the specimens.

Morphology of the ATN

One-root ATN. Eight of the nine one-root ATN specimens originated from the mandibular nerve, while the remaining one originated from the inferior alveolar nerve.

Two-root ATN. Seven of the 14 two-root specimens displayed both roots originating from the mandibular nerve. The remaining specimens showed the first root originating from the mandibular nerve and the second from the inferior alveolar nerve. All specimens with a two-root ATN had a V-shape formation, but the MMA was only found to pass through eight (Fig. 1).

Three-root ATN. Seven specimens had three-root ATN (Table 1). However, only three specimens were discovered with all roots originating from mandibular nerve. The first root of the remaining four specimens originated from the mandibular nerve and the two inferior roots from the inferior alveolar nerve. All specimens had a V-shape formation; however, the MMA only passed through four.

Four-root ATN. Only two specimens displayed four-root ATN with their first root from the mandibular nerve, and their third and fourth roots originating from the inferior alveolar nerve. However, in one specimen, the second root originated from the mandibular nerve, while another originated from the inferior alveolar nerve. Both specimens exhibited V-shaped formations, but only one had the MMA passing through.

Morphometry of the ATN

The mean distances measured between the roots of the ATN are shown in Table 2. The mean distance between the first and second roots of the ATN was found to be the largest, while the distances between the third and fourth roots were the smallest.

Relationship between the ATN's roots and the MMA or maxillary artery

The observations of the relationship between the ATN and MMA are depicted in Table 3. However, it is noted that particular specimens were also related to the maxillary artery.

In a two-root specimen, the second root of the ATN was superficial to both the MMA and maxillary artery. Two specimens had their second roots deep to the maxillary artery and were, therefore, unrelated to the MMA. The second root of another specimen, which originated from the mandibular nerve, split into a buttonhole but did not contain any vasculature.

The second root in a three-root specimen was superficial to the maxillary artery and anterior to the MMA. Furthermore, the second root of the ATN in two specimens was closely related to the maxillary artery — one was deep to the maxillary artery, and another was inferior. The third roots of four specimens were also closely related to the maxillary artery — two were superficial, one was deep, and one inferior to the maxillary artery.

Table 2. Mean distances measured between the first and second, second and third, and third and fourth roots of the auriculotemporal nerve (ATN) [mm]

	One-root ATN	Two-root ATN		Three-root ATN			Four-root ATN				Total
	First root	First root	Second root	First root	Second root	Third root	First root	Second root	Third root	Fourth root	
Superficial to MMA	9	13	1	6	2	–	2	–	–	–	33
Deep to MMA	–	1	10	–	1	3	–	2	2	1	20
Anterior to MMA	–	–	1	1	1	1	–	–	–	1	5

MMA — middle meningeal artery

Table 3. Relationship between roots of the one-, two-, three-, and four-root auriculotemporal nerve and the middle meningeal artery in dissected infratemporal fossae

	Measurement [mm] Mean ± SD
Distance between the first and second roots	4.69 ± 5.24
Distance between the second and third roots	3.63 ± 3.89
Distance between the third and fourth roots	2.67 ± 2.06

SD — standard deviation

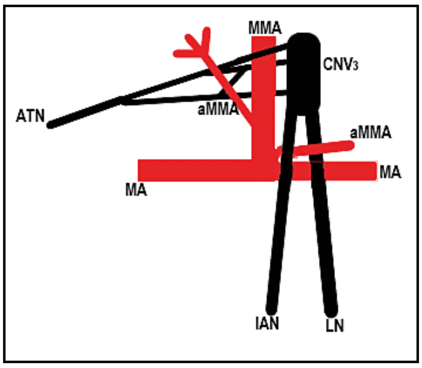

Figure 2. Schematic representation of the three-root auriculotemporal nerve (ATN) variant. The second root bifurcated — upper part joined first root and lower part joined third root. Middle meningeal artery (MMA) passed through V-shape created between the first and second roots; MA — maxillary artery; aMMA — accessory middle meningeal artery; CNV_3 — mandibular nerve; IAN — inferior alveolar nerve; LN — lingual nerve.

Course of the maxillary artery

The maxillary artery often coursed deep to the lateral pterygoid muscle in the studied sample (Table 1). Of the 19 deep course specimens, the maxillary arteries coursed through a loop formed in the inferior alveolar nerve in six specimens.

Presence of the aMMA

The aMMA was present in 14 (43.75%) specimens (Table 1). A double aMMA was found in one specimen, which coursed superiorly, superficial to the ATN, and trifurcated (Fig. 2). Hence, 15 aMMA was encountered in this study.

DISCUSSION

The ATN has been described to originate as two roots from the mandibular nerve, forming a buttonhole to enclose the MMA [8, 18]. However, many studies have discovered that the ATN can arise from as few as one to as many as five roots [12, 16]. The two-root ATN is the most prevalent in the American, Turkish, Polish, New Zealand, Indian, and Thai populations [2, 6, 7, 9, 12, 16]. This correlated with the present study, as a prevalence of 43.75% was documented. Furthermore, the ATN can originate from the inferior alveolar and mandibular nerves [6, 7, 12], which was shown to be true in the present study. This study demonstrated that the first root of the ATN originated from the mandibular nerve and the inferior roots from the inferior alveolar nerve. This corroborated with Komarnitki et al. [12], Dias et al. [7], and Chanasong et al. [6] who found that the inferior alveolar nerve contributes to the main trunk of the ATN. Although, Quadros et al. [16] discovered that the inferior alveolar nerve was a point of origin of all the ATN in their population. The inferior alveolar nerve's contribution to the ATN could explain unexpected ATN neuralgia resulting from an inferior alveolar nerve block [15].

The morphometric distance measured between the roots of the auriculotemporal nerve suggested that the distance between the inferior roots is smaller than that of the superior roots. The mean distance between all the roots of the ATN was 4.42 mm in the present study, while Baumel et al. [2] and Gulekon et al. [9] found that the distance between the roots of the auriculotemporal nerve was 3.92 mm and 4.12, respectively. The difference in measurements amongst the various populations may suggest that morphometric distances may be affected by ethnicity.

Previous research has described the relationship between the roots of the ATN and the MMA as either superficial or deep to the artery [2, 7, 9, 16]. The present study further included a description of the roots being anterior to the artery. However, this study also demonstrated that the superior roots are usually superficial to the MMA, whereas the inferior roots are deep. These results corroborated with Baumel et al. [2] and Gulekon et al. [9]. Furthermore, the anatomical relationship of the three-root ATN to the MMA in a South African population is similar to that of the American population — the superior two roots are superficial to the MMA, and the inferior root is deep [2]. Contrarily, the first root in the Turkish population was superficial to the MMA, while the lower two were deep [9], while the Indian population showed one root being deep and two superficial to the MMA [16]. As a result, there is a great deal of variation in the relationship between the ATN roots and the MMA.

In agreement with previous literary reports, the typical buttonhole formation was not discovered in the present South African population [2, 7, 12]. The most common interval formed by the roots of the ATN in this study was a V-shape, as found in previous studies [2, 7, 12]. Although the V-shape was found in 22/32 of the selected sample, the MMA was only enclosed in 14 (63.64%). Dias et al. [7] and Chanasong et al. [6] found the MMA enclosed in 52.00% and 69.86% of their specimens, respectively. The findings of this study support previous research stating that the buttonhole is seldom present and that the MMA does not always pass through the ATN [2, 7, 12].

Although Baumel and Beard [1] concluded that the aMMA is commonly present, it was only found in 43.75% in the present study. Similarly, Chanasong et al. [6] discovered an aMMA in 21.91% of their sample. The aMMA may also arise in equal parts from the MMA and the maxillary artery [1]. However, Chanasong et al. [6] discovered that the aMMA arose more frequently from the MMA (75.00%). This study also found the aMMA frequently originating from the MMA (53.33%) in the South African population. Baumel and Beard [1] suggested that the course of the maxillary artery in relation to the lateral pterygoid muscle determined the origin of the aMMA. When the maxillary artery was superficial to the lateral pterygoid muscle, the aMMA arose from the MMA. However, the aMMA arose from the maxillary artery when the maxillary artery coursed deep to the lateral pterygoid muscle [1]. This relationship was also demonstrated in the current study.

CONCLUSIONS

This study examined the relationship between the MMA and the ATN in a South African population and added pivotal information on the contents of the infratemporal fossa in a South African population which may be beneficial to anatomists and surgeons. The findings of this study indicated several variations in the morphology of the ATN and its relationship to the MMA, which are similar to those found in population groups previously studied. The results of this study further highlighted that the variations of the ATN and the MMA are not concisely documented in standard anatomical literature.

Limitations and recommendations

Due to the limited sample size, no significant differences could be found between the individuals' sexes, sides, and ethnicities. However, the findings of this study may aid future research in discovering ethnic differences. Hence, the recommendation made for future studies is to utilise a bigger sample size to determine if there are significant differences in laterality, age, sex, and population groups. Due to the paucity of literature on the ATN and MMA, ethnic differences have not been previously established. This study, therefore, adds to the existing literature by discovering the morphology of the ATN and MMA in a South African population which may be useful for future studies examining population differences.

Ethical approval

This study was performed in line with the principles of the Declaration of Helsinki. The Biomedical Research Ethics Committee of the University of KwaZulu-Natal (BREC/00002919/2021) granted ethical approval for this study.

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Conflict of interest: None declared

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