The relationship between the Auriculotemporal nerve and Middle Meningeal artery in a sample of the South African population

by

Sherelle Moodley

217004886

Supervisor:

Dr P. Pillay

Co-supervisor:

Ms S. Ishwarkumar

Submitted in fulfilment of the requirements for the degree of Master of Medical Science (Anatomy) in the School of Laboratory Medicine and Medical Sciences, University of KwaZulu-Natal

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DECLARATION

I, Ms Sherelle Moodley, declare as follows:

1. That the work described in this dissertation has not been submitted to UKZN or other tertiary institution for purposes of obtaining an academic qualification, whether by myself or any other party.

2. That my contribution to the project was as follows:

   Development and design of the research protocol
   Collection, analysis, and interpretation of the data
   Formulation of the manuscripts
   Compilation of the dissertation

3. That the contributions of others to the project were as follows:

   Dr P. Pillay (Supervisor), Mrs S. Ishwarkumar (Co-supervisor):

   Conceptualization of research topic, consultations, and research advice
   Assistance with the editing, structuring, and planning of the dissertation and manuscripts
   Provided guidance and constructive criticism
   Reviewed the dissertation and manuscripts prior to submission

Signed  Date 27/09/2022

DEDICATION

To my family for their constant support and prayers throughout this journey.

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LIST OF ABBREVIATIONS

ATN	:	Auriculotemporal nerve
aMMA	:	Accessory middle meningeal artery
CNV	:	Trigeminal nerve
CNV_1	:	Ophthalmic nerve
CNV_2	:	Maxillary nerve
CNV_3	:	Mandibular nerve
IAN	:	Inferior alveolar nerve
ITF	:	Infratemporal fossa
LPM	:	Lateral pterygoid muscle
MMA	:	Middle meningeal artery
TMJ	:	Temporomandibular joint

ABSTRACT

Introduction: Within the infratemporal fossa, the auriculotemporal nerve arises as two roots from the mandibular division of the trigeminal nerve and forms a buttonhole through which the middle meningeal artery courses. Thereafter, the two roots of the auriculotemporal nerve re-join and proceeds to provide sensory innervation to multiple structures of the head. The middle meningeal artery branches from the maxillary artery and enters the cranium through foramen spinosum. Variations of the auriculotemporal nerve and the middle meningeal artery have been documented in several populations. However, there is a paucity of literature regarding the South African population group. The aim of this study was to document the relationship between the auriculotemporal nerve and the middle meningeal artery and their variations (if any) within a South African population. **Materials and methods:** Sixteen (n=32) adult cadavers were dissected to reveal the infratemporal fossae regions. The auriculotemporal nerve and middle meningeal arteries were observed, and the morphology and morphometry were documented. **Results:** The auriculotemporal nerve arose as one to four roots. The most common variation was the two-root auriculotemporal nerve ($^{14}/_{32}$; 43.75%). The inferior alveolar nerve was observed to contribute to the formation of the auriculotemporal nerve in the majority of the individuals. The roots of the auriculotemporal nerve were either anterior, deep, or superficial to the middle meningeal artery. Although the V-shapes were present in $^{23}/_{32}$ infratemporal fossae, only $^{13}/_{32}$ middle meningeal arteries passed through them. In the South African cohort, the maxillary artery was found to course deep to the lateral pterygoid muscle in $^{19}/_{32}$ (59.38%) individuals and superficial in $^{13}/_{32}$ (40.63%). Fifteen accessory middle meningeal arteries were present in $^{14}/_{32}$ (43.75%) infratemporal fossae – one individual displayed a double accessory middle meningeal artery. The accessory middle meningeal artery originated from the middle meningeal artery or the maxillary artery in ($^{8}/_{15}$) 53.33% and ($^{7}/_{15}$) 46.67% of the individuals, respectively. **Conclusion:** This study showed numerous anatomical variations of the neurovasculature within the infratemporal fossa. Furthermore, this study provides novel information about the auriculotemporal nerve and middle meningeal artery in a South African population, which has not been previously reported. The results may be beneficial to medical professionals during surgical interventions to the infratemporal fossa.

CHAPTER 1

1.1 Introduction

1.1.1. Background

The auriculotemporal nerve (ATN) originates as two roots from the mandibular nerve, forming a buttonhole around the middle meningeal artery (MMA) before merging to form the main trunk (Ellis and Lawson, 2013; Standring et al., 2016). The ATN is present within the infratemporal fossa, coursing posterior to the lateral pterygoid muscle and anterior to the tensor veli palatini muscle (Standring et al., 2016). Although the relationship between the ATN and MMA in many population groups has been observed (Gulekon et al., 2005; Chan et al., 2013; Thotakura et al., 2013; Bhardwaj et al., 2014; Dias et al., 2015; Komarnitki et al., 2015), it is not documented in a South African cohort.

Contrary to standard anatomical texts, variations in the morphology of the ATN have been described in several literary reports, showing that the nerve does not always originate as two roots (Baumel et al., 1971; Gulekon et al., 2005; Dias et al., 2015; Komarnitki et al., 2015). The ATN has been discovered to arise from as many as five roots from the mandibular nerve, with some contribution from the inferior alveolar nerve (Kim et al., 2003; Gulekon et al., 2005; Chan et al., 2013; Thotakura et al., 2013; Bhardwaj et al., 2014; Dias et al., 2015; Komarnitki et al., 2015). The presence of several nerve loops within the infratemporal fossa is not unexpected, considering that multiple roots may be forming the ATN (Soni et al., 2009).

In addition, the relationship between the ATN and MMA depicted in several studies revealed that the roots of the ATN do not form a close interaction with the MMA (Gulekon et al., 2005; Chan et al., 2013; Thotakura et al., 2013; Bhardwaj et al., 2014; Dias et al., 2015; Komarnitki et al., 2015). Several authors have discovered a variation in the shape formed by the ATN for the passage of the MMA, describing it as a V-shape interval (Baumel et al., 1971; Dias et al., 2015; Chanasong et al., 2020). Among other possible vascular structures that may be enclosed by the roots of the ATN besides the MMA, the maxillary artery is common (Baumel et al., 1971). Although several studies have reported variations in the anatomy of the ATN, the authors did not determine if laterality or ethnicity affects these variations.

The complex anatomy of the infratemporal fossa contributes to difficulties in surgical procedures within this area (Joo et al., 2013). Due to the extensive neurovascular structures and borders of the infratemporal fossa, tumours and infections can originate in or progress to this area (Bozkurt et al., 2019). Meningiomas developing within the cranium can progress into the infratemporal fossa through the foramen ovale, causing mandibular nerve entrapment (Hitotsumatsu and Rhoton, 2000).

Furthermore, entrapment of the mandibular nerve and trismus are common symptoms associated with the presence of abnormal masses in the infratemporal fossa (Piagkou et al., 2011b).

Although the ATN is rarely involved in parotid gland cancer, a perineural tumour progressing along the ATN and extending cranially to the foramen ovale is possible (Chan et al., 2013; Thompson et al., 2019). The proliferation of a tumour along the ATN can harm structures in the infratemporal fossa, cause mandibular nerve palsy, and displace or obliterate vascular structures (Tiwari, 1998; Schmalfuss et al., 2002). Additionally, pressure from vascular structures may cause trigeminal neuralgia due to the close relationship between the trigeminal neurovasculature (Somayaji et al., 2012). Owing to the high incidence of a perineural tumour spread and the resulting high mortality rate, knowledge of the anatomy of the ATN and its connection with other nerves is essential for surgeons in planning suitable modes of treatment for the tumour (Chan et al., 2013). Hence, the close contact between the roots of the ATN to the MMA may cause further complications as a tumour extending along the ATN may cause constriction of the MMA, affecting the areas supplied by the artery.

Hearing loss, facial nerve paralysis, and temporomandibular joint dysfunction are results of surgical complications in the infratemporal fossa (Piagkou et al., 2011a). Owing to the potential for major surgical complications, variations of the neurovasculature in the infratemporal fossa can be of practical significance to surgeons and neurologists dealing with this complex area (Piagkou et al., 2011a). It is vital to be knowledgeable of the morphology of the ATN, its relationship with the MMA, and the anatomy of the infratemporal fossa to enable medical personnel to precisely identify the neurovascular structures and limit the risk of complications during procedures involving the infratemporal fossa.

1.2 Literature Review

1.2.1 Anatomy of the infratemporal fossa

The infratemporal fossa is defined by the lateral pterygoid plate, the zygomatic bone, and the posterior surface of the maxillary sinus, anteriorly; the ramus of the mandible, laterally; the styloid process and temporal bone, posteriorly; and the greater wing of the sphenoid bone and part of the temporal bone, superiorly (Joo et al., 2013; Fang et al., 2019). There is no inferior boundary forming the anatomical floor of the infratemporal fossa. Hence, this region is able to communicate with various adjacent anatomical spaces, such as the temporal fossa, superolateral; the orbit, superiorly; and the pterygopalatine fossa, medially (Standring et al., 2016). Contents of the infratemporal fossa includes essential head and neck muscles and neurovasculature, *viz.*, the mandibular nerve and maxillary artery (Joo et al., 2013; Fang et al., 2019). The muscles within the infratemporal fossa includes the lateral and medial pterygoid muscles (Standring et al., 2016). The greater wing of the sphenoid bone contains the foramen ovale and foramen spinosum, which acts as passageways for the mandibular nerve and the MMA, respectively (Joo et al., 2013).

The branches of the mandibular nerve are frequently entrapped in the fibres of the lateral pterygoid due to their close interaction with the muscle (Loughner et al., 1990; Piagkou et al., 2011b). Therefore, the complicated anatomy of the infratemporal fossa and the variability of containing structures in anatomical relation to each other contribute to the frequent nerve entrapment (Loughner et al., 1990; Piagkou et al., 2011b). Due to the extensive neurovasculature within the infratemporal fossa, a detailed understanding of the relationship between the nerves and blood vessels is essential to anaesthetists to avoid any complications that may arise, such as a hematoma formation if a blood vessel is damaged during nerve blocks. Knowledge of the neurovasculature in the infratemporal fossa and possible morphological variations may provide insight into managing these structures during surgeries and reducing the risk of neuralgia and other critical symptoms (Fang et al., 2019).

1.2.2 Anatomy of the Auriculotemporal nerve

Although sensory nerve fibres make up most of the trigeminal nerve, the mandibular nerve is also responsible for the motor innervation of various muscles (Piagkou et al., 2011b). The three main branches of the trigeminal nerve are the ophthalmic, maxillary, and mandibular nerves, which exit the middle cranial fossa through the superior orbital fissure, foramen rotundum and foramen ovale, respectively (Romano et al., 2019). Thereafter, the largest branch of the trigeminal nerve – the

mandibular nerve – enters the infratemporal fossa and divides into a smaller anterior and a larger posterior division to provide the muscles of mastication with motor innervation and the lower lip, as well as the skin over the mandible, mandibular dentition, gingivae, and cheek with cutaneous innervation (Piagkou et al., 2011a; Standring et al., 2016). The ATN originated as one of the cutaneous branches of the posterior division of the mandibular nerve within the infratemporal fossa and has sensory, vasomotor and parasympathetic functions (Dias et al., 2015; Standring et al., 2016). The lingual and inferior alveolar nerves are other sensory nerves of the mandibular nerve (Romano et al., 2019).

Following its origin as two roots from the posterior division of the mandibular nerve, the ATN forms a buttonhole for the passage of the MMA before re-joining to form its main trunk, which then coursed between the sphenomandibular ligament and the neck of the mandible (Figure 1) (Dias et al., 2015). Thereafter, the ATN emerged onto the face, inferior to the mandibular condyle, and is located within the superior aspect of the parotid gland, to which it provides parasympathetic innervation (Janis et al., 2010; Ellis and Lawson, 2013; Standring et al., 2016). The ATN proceeds to course superiorly, lying superficial to the zygomatic arch and posterior to the superficial temporal blood vessels (Standring et al., 2016). The ATN then terminates as its superficial temporal branches, which lay adjacent to the superficial temporal artery and vein (Standring et al., 2016). Cutaneous innervation is supplied to the tympanic membrane, temporomandibular joint, tragus, crus, the adjacent region of the helix and the posterior half of the temple by the main branches of the ATN, *viz.*, the branches to the external acoustic meatus, articular, anterior auricular, and superficial temporal, respectively (Janis et al., 2010; Ellis and Lawson, 2013; Standring et al., 2016).

Standard anatomical textbooks have stated that the two rooted ATN solely developed from the posterior division of the mandibular nerve; however, recent literature has suggested otherwise (Gulekon et al., 2005; Chan et al., 2013; Thotakura et al., 2013; Bhardwaj et al., 2014; Dias et al., 2015; Komarnitki et al., 2015). Variations in the morphology of the ATN and its relationship to the MMA have been discovered to differ from standard anatomical texts, including the number of roots forming the ATN and the morphology of the roots (Baumel et al., 1971; Gulekon et al., 2005; Dias et al., 2015; Komarnitki et al., 2015).

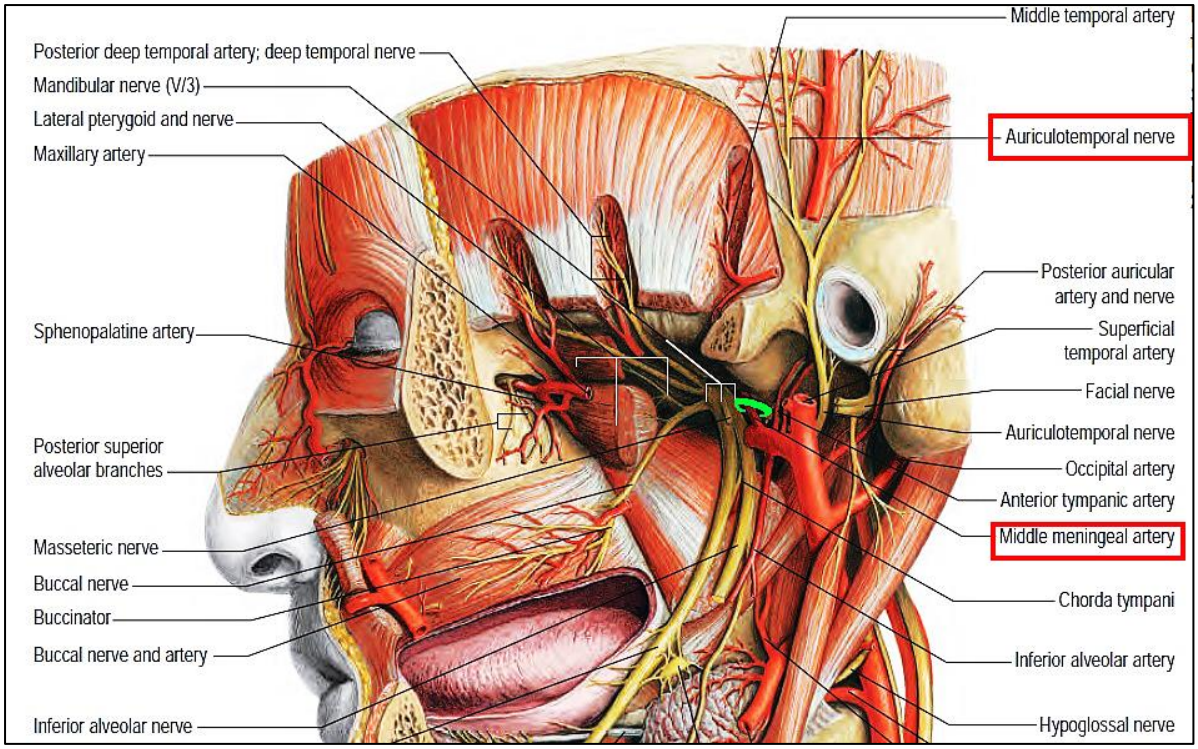

Figure 1: The mandibular nerve within the infratemporal fossa and the ATN, which formed a buttonhole (green circle) around the MMA (Adapted from Standring et al. (2016)).

Although the ATN originated from as less as one to as many as five roots, the two-root model was the most common variation observed in multiple studies (Baumel et al., 1971; Gulekon et al., 2005; Dias et al., 2015; Komarnitki et al., 2015). Komarnitki et al. (2012), however, found that the one- and two-root ATN models were equally displayed in five individuals ($^{5}/_{16}$). This suggests that the one-root ATN may also be a common variation in various populations. Furthermore, regardless of the number of primary roots, Komarnitki et al. (2015) suggested that the main trunk of the ATN was only created by one to three secondary roots. However, a thorough understanding of the origin of the primary roots of the ATN is essential in planning nerve blocks to the mandibular nerve and managing related symptoms.

Studies have shown that the mandibular and the inferior alveolar nerves gave rise to the roots of the ATN – the superior root of the ATN from the former and the inferior root from the latter (Kim et al., 2003; Gulekon et al., 2005; Chan et al., 2013; Thotakura et al., 2013; Bhardwaj et al., 2014; Dias et al., 2015; Komarnitki et al., 2015). Consequently, this implied that the ATN does not solely originate from the mandibular nerve, as multiple studies discovered otherwise (Kim et al., 2003; Gulekon et al., 2005; Chan et al., 2013; Thotakura et al., 2013; Bhardwaj et al., 2014; Dias et al., 2015; Komarnitki et al., 2015). This variation in the origin of the ATN could explain inferior alveolar nerve block complications and the consequential anaesthesia of the ATN (Kim et al., 2003; Gulekon et al.,

2005; Chan et al., 2013; Thotakura et al., 2013; Bhardwaj et al., 2014; Dias et al., 2015; Komarnitki et al., 2015).

Due to the close relationship between the mandibular nerve and the lateral pterygoid muscle, branches of the mandibular nerve and its resulting nerve loops are frequently entrapped within the lateral pterygoid muscle (Kalra et al., 2014). Therefore, a proper understanding of the ATN's complicated and abnormal nerve connections is critical for surgeons to undertake successful treatments (Thotakura et al., 2013). Although variations of the ATN have been previously studied in several population groups, there are no variations recorded in the South African population. Knowledge of the anatomy of the ATN and its variations is essential to surgeons in operations in the infratemporal fossa, the temporomandibular joint, parotidectomies, and nerve blocks.

1.2.3 Anatomy of the maxillary and Middle meningeal arteries

The maxillary artery is the largest branch of the external carotid artery, arising posterior to the mandibular neck and passing through the infratemporal fossa to terminate in the pterygopalatine fossa via the pterygomaxillary fissure (Joo et al., 2013). It is divided into three parts: first or mandibular, second or pterygoid, and third or pterygopalatine (Joo et al., 2013). Within the infratemporal fossa, the maxillary artery coursed superficial or deep to the lateral pterygoid muscle, influencing the origin of the accessory middle meningeal artery (Allen et al., 1973). In its superficial course, the first part of the maxillary artery passed deep to the ramus of the mandible and between the neck of the mandible and the sphenomandibular ligament (Standring et al., 2016). The maxillary artery lay in close proximity to the inferior alveolar nerve and coursed along the inferior border of the lateral pterygoid muscle in the infratemporal fossa (Standring et al., 2016). The deep auricular, anterior tympanic, middle meningeal, accessory middle meningeal, and inferior alveolar arteries are said to arise from the mandibular part of the maxillary artery (Joo et al., 2013; Standring et al., 2016). Thereafter, the second part of the maxillary artery coursed anteriorly in the infratemporal fossa and lies medial to the attachment of the temporalis muscle onto the coronoid process of the mandible. However, for the deep variation, the maxillary artery coursed between the lateral pterygoid muscle and the branches of the mandibular nerve (Standring et al., 2016).

The MMA is generally the first branch of the maxillary artery and supplies the cerebral dura mater by entering the cranium through the foramen spinosum (Joo et al., 2013; Standring et al., 2016). After passing through the interval of the ATN, the MMA travels laterally to the tensor veli palatini muscle to

enter the middle cranial fossa via the foramen spinosum (Standring et al., 2016). Intracranially, the branches of the MMA supplied the periosteum and the bones of the cranium (Standring et al., 2016).

Variations in the anatomy of the MMA have been previously documented in the literature. Maeda et al. (2012), amongst other authors, have noticed variable origins of the MMA (Table 1). Along with its various origins, the MMA can enter the cranium through other foramina besides the foramen spinosum. The most common entry points into the cranium were the meningo-orbital foramen (Low, 1946) and the superior orbital fissure (Royle and Motson, 1973). Anomalous origins of the MMA have been found since 1946 (Low, 1946) and may be attributed to its complex embryological development (Bonasia et al., 2020).

Table 1: Anomalous origins of the MMA discovered in previous literature

Author	Origin of MMA
Low (1946)	Third part of maxillary artery
Royle and Motson (1973)	Lacrimal artery
Shah and Hurst (2007)	Pontine artery
Kuruvilla et al. (2011)	Posterior inferior cerebellar artery
Maeda et al. (2012)	Superficial temporal artery

The accessory middle meningeal artery can branch from the maxillary or the MMA and ascend into the cranium via the foramen ovale to supply intracranial structures, such as the dura of the temporal region and the trigeminal ganglion, and extracranial structures, such as the lateral pterygoid, medial pterygoid, and the tensor veli palatini muscles (Baumel and Beard, 1961; Dilenge and Géraud, 1975; Standring et al., 2016). Within its course, the accessory middle meningeal artery was superficial to the inferior alveolar and lingual nerves (Baumel and Beard, 1961). The accessory middle meningeal artery was responsible for blood supply to meningiomas of the temporal fossa and the trigeminal ganglion (Dilenge and Géraud, 1975). Hence, knowledge of the course of the maxillary artery, the origin of the accessory middle meningeal artery, and their incidence within a population are critical in intracranial tumour resection and surgical procedures within the infratemporal fossa due to their close relationship to the mandibular nerve.

Furthermore, Baumel and Beard (1961) stated that the accessory middle meningeal artery was present in the majority of the population. Baumel and Beard (1961) described the accessory middle meningeal artery as arising directly from the MMA or the first or second parts of the maxillary artery and observed the accessory artery in 96.00% of their individuals. Additionally, multiple accessory middle meningeal arteries may be present within an individual. Baumel and Beard (1961) recorded up to four accessory middle meningeal arteries in one individual. The incidence of multiple middle meningeal arteries within the infratemporal fossa should be considered when planning surgical interventions in the region of the infratemporal fossa.

1.2.4 The relationship between the Auriculotemporal nerve and Middle meningeal artery

Although the ATN formed an interval for the passage of the MMA, the MMA does not always course through it. The MMA may be situated deep or superficial to the roots of the ATN. Apart from the standard buttonhole formation, other shapes of the ATN may be observed (Baumel et al., 1971; Dias et al., 2015; Chanasong et al., 2020) (Table 2). The relationship between the ATN and MMA has, therefore, been shown to be variable within population groups (Baumel et al., 1971; Dias et al., 2015; Chanasong et al., 2020).

Table 2: Interval shapes of the ATN identified in various population groups.

Author	Sample size	Shape formation often found in the sample	Population group
Baumel et al. (1971)	85	V-shape	American
Dias et al. (2015)	25	Triangle	New Zealand
Chanasong et al. (2020)	73	V-shape	Thai

Baumel et al. (1971) reported that in the two-root ATN, the roots forming the nerve originated from the mandibular or the inferior alveolar nerves, enclosed the MMA in a V-shape and re-joined. Dias et al. (2015) established that although a buttonhole may be present within the infratemporal fossa, the MMA does not always pass through it. On two occasions, the root originating from the mandibular nerve in the two-root ATN formed a buttonhole but did not enclose the MMA (Dias et al., 2015). Moreover, the triangle shape encountered by Dias et al. (2015) can be concluded as the V-shape formation discovered by several other authors (Baumel et al., 1971; Chanasong et al., 2020). Previous studies, therefore, suggested that the MMA was not always enclosed within a buttonhole formed by the ATN as described

in standard anatomy texts but may be contained within a triangle- or a V-shaped interval (Baumel et al., 1971; Dias et al., 2015; Chanasong et al., 2020).

Although literary reports often suggested that the MMA is enclosed by the roots of the ATN, Dias et al. (2015) observed that the MMA coursed near the ATN rather than through the interval formed in two individuals. Furthermore, the MMA was found to pierce only the upper root of the ATN in a few cases (Baumel et al., 1971). The MMA was observed coursing deep to the roots of the ATN in many individuals (Dias et al., 2015) and corroborated the findings of Baumel et al. (1971). When the ATN originated from more than one root, several authors reported that all the roots may pass superficial to the MMA, deep to the MMA, or a combination of both (Baumel et al., 1971; Gulekon et al., 2005; Dias et al., 2015; Quadros et al., 2016). Knowledge of the anatomical association between the roots of the ATN to the MMA is essential in determining the relationship between the two neurovascular structures.

Additionally, an ATN possessing multiple roots can form several loops with each other (Soni et al., 2009; Nallagatla et al., 2015), increasing the risk of ATN entrapment and neuralgia (Piagkou et al., 2011a). Bhardwaj et al. (2014) observed that the ATN, bilaterally in one of their cadavers, was formed by two roots – one from the mandibular nerve and one from the inferior alveolar nerve – which created a loop and did not contain any vascular structures. These further emphasised that the MMA may not be contained within the interval created by the ATN. Additional structures, such as the maxillary artery and connective tissue, may be present in the intervals created by the ATN (Baumel et al., 1971; Dias et al., 2015). The association of nerves and arteries is critical in the progression of perineural tumours, and the close association between the ATN and MMA may cause additional surgical complications (Schmalfuss et al., 2002). Therefore, medical practitioners should be aware of the varied morphology of the ATN and its relationship to the MMA so as to avoid further complications within the infratemporal fossa during surgical interventions (Komarnitki et al., 2015).

1.3 Problem Statement

Knowledge of the ATN and MMA's relationship and their variations is vital in analyses of perineural tumour spreads (Schmalfuss et al., 2002), performing nerve blocks (Kim et al., 2003) and surgical procedures in the infratemporal fossa (Fang et al., 2019). Anatomical variations are influenced by geographic region and race (Alraddadi, 2021), and ten percent of surgical errors are caused by a lack of understanding of anatomical variations (Cahill and Leonard, 1999). Ethnicity and laterality may further affect the relationship between the ATN and the MMA and their variations. However, the ATN and MMA in a South African population have not been previously researched. Hence, the purpose of this dissertation was to examine the morphology and morphometry of the ATN and MMA in a South African population. Furthermore, this dissertation sought to analyse the effects of laterality and ethnicity on the morphology and morphometry of the ATN and MMA and their relationship.

1.4 Aim

To document the relationship between the ATN and MMA within the infratemporal fossa in a South African population of KwaZulu-Natal.

1.5 Objectives

The following research objectives were formulated for this dissertation:

- To document and describe the relationship between the ATN and MMA in a cadaveric South African population of KwaZulu-Natal via dissection;
- To analyse the effect of laterality on the morphometry and morphology of the ATN and MMA; and
- To note any variations observed in the ATN and MMA.

1.6 Research Questions

The following research questions were formulated for this dissertation:

- What is the anatomical relationship between the ATN and MMA?
- What variations of the ATN and MMA are present in a South African population?

1.7 Materials and Methods

Sixteen bilateral adult cadaveric South African individuals (n=32) were obtained from the Department of Clinical Anatomy, University of KwaZulu-Natal, and dissected for this study. Ethical approval for this study was obtained from the Biomedical Research Ethics Committee of the University of KwaZulu-Natal (BREC/00002919/2021) (Appendix A).

The cadavers' age, sex and ethnicity were recorded. Of the individuals, 8 were males, and 8 were females. The ages of the cadavers ranged from 47 – 91. Regarding the cadavers' ethnicity, 14 were South African White, and 2 were South African Black. The cadavers were dissected to expose the infratemporal fossae and analyse the ATN and MMA. The ramus of the mandible was dissected using a bone saw, and underlying muscles were removed to expose the infratemporal fossa. The morphometric and morphological observations were recorded. The distance between the roots of the ATN was measured using a digital vernier calliper (EIS Digital Vernier Caliper [0 – 150mm], accuracy ± 0.001in [0.02mm]). The morphology of the ATN (*viz.*, number of roots forming the ATN, origin of the roots, communication between roots, and shape formation of the roots – buttonhole or V-shape), together with its relationship to the MMA, within the boundaries of the infratemporal fossa, was observed and recorded. The presence of an accessory middle meningeal artery was observed and documented, including its point of origin and relationship to the mandibular nerve.

1.8 Organisation of this Dissertation

The dissertation has been prepared according to the University of KwaZulu-Natal's College of Health Science guidelines (Appendix B), which stipulates a manuscript formatted dissertation. This study examined the anatomical morphology and morphometry of the ATN and its relationship to the MMA in an adult cadaveric South African cohort. Any variations present in the above-mentioned neurovasculature were also analysed.

Chapter 1

This chapter included a background, literature review, the aim and objectives of the dissertation, and a concise methodology.

Chapter 2

This manuscript investigated the relationship between the ATN and the MMA in 32 cadaveric South African samples. This study further analysed the variations in the anatomy of the ATN and MMA. The objective of this paper was to document the relationship between the ATN and the MMA and note any anatomical variations thereof. This manuscript was submitted to the *Journal of Anatomy* (manuscript number: JANAT-2022-0344) (Appendix C).

Chapter 3

This chapter included a synthesis and conclusion of the dissertation, as well as the references for chapters one and three.

CHAPTER 2

Although variations of the ATN and the MMA have been previously recorded in various population groups, to the best of the authors' knowledge, no studies have investigated the morphology and morphometry of the ATN and the relationship between the ATN and MMA in a South African sample. Hence, this manuscript, entitled "The relationship between the auriculotemporal nerve and middle meningeal artery in a South African population," aimed at investigating the relationship between the ATN and MMA, the morphometry and morphology of the ATN, and any variations present in the South African population.

This manuscript was submitted to the *Journal of Anatomy* in September 2022 (Manuscript number: JANAT-2022-0344) (Appendix C). The following manuscript followed the guidelines stipulated by the *Journal of Anatomy* (Appendix C).

1 **1. TITLE PAGE**

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Authors : S Moodley[1], S Ishwarkumar[2], P Pillay[1]

Name of institution : [1] Department of Clinical Anatomy

School of Laboratory Medicine and Medical Sciences

College of Health Sciences

University of KwaZulu-Natal

Westville Campus

Private Bag X54001

Durban

4000

[2] Department of Human Anatomy and Physiology

Faculty of Health Sciences

University of Johannesburg

Doornfontein Campus

P.O Box 524

Auckland Park

South Africa

2006

Total number of figures : 4

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Corresponding author : Dr Pamela Pillay

Department of Clinical Anatomy

School of Laboratory Medicine and Medical Sciences

College of Health Sciences

University of KwaZulu-Natal

Westville Campus

Private Bag X54001

Durban

4000

Telephone number : +27 31 260 7789

Email address : soobramoneypa@ukzn.ac.za

2. ABSTRACT

The interaction between the auriculotemporal nerve and the middle meningeal artery within the infratemporal fossa is vital in the spread of perineural tumors. 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. The infratemporal fossae of 32 cadaveric individuals were dissected and the auriculotemporal nerves and middle meningeal arteries were analyzed, together with their variations. Nine out of 32 individuals 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 from the inferior alveolar nerve. The mean distance between the first and second roots of the auriculotemporal nerve was 4.69mm. 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. The accessory middle meningeal artery was present in 14/32 individuals, with one exhibiting a double accessory middle meningeal artery. The accessory middle meningeal artery often arose from the middle meningeal artery (46.67%). 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.

3. KEYWORDS: Infratemporal fossa, Mandibular nerve, Maxillary artery, Meningeal arteries, Neoplasms

4. MAIN BODY

INTRODUCTION

In 2020, the number of people diagnosed with salivary cancer increased globally by 53 584 (WHO, 2020). The cumulative risk of cancer in South African males is 0.04% more than in females (WHO, 2020). However, half of all parotid gland tumors in South African men are malignant (Van Lierop and Fagan, 2007). Although the auriculotemporal nerve (ATN) is rarely involved in parotid gland cancer, a perineural tumor spread along the ATN may extend cranially to the foramen ovale, where the mandibular branch of the trigeminal nerve (CNV_3) passes (Chan et al., 2013; Thompson et al., 2019). The progression of a tumor along the ATN can compromise tissues in the infratemporal fossa (ITF), cause CNV_3 palsy, and displace or obliterate vascular structures (Tiwari, 1998; Schmalfuss et al., 2002). The interaction of nerves and vessels is critical in the spread of perineural tumors, and the close association between the ATN and the middle meningeal artery (MMA) may cause additional complications (Schmalfuss et al., 2002). As a result, medical practitioners must understand the morphology of the ATN and its relationship to the MMA, as well as the anatomy of the ITF, to appropriately identify the neurovasculature and limit the risk of complications during ITF procedures. However, the relationship between the ATN and MMA has not been investigated in a South African population.

The auriculotemporal, inferior alveolar (IAN), and lingual nerves are the cutaneous branches of the posterior division of the CNV_3 (Ellis and Lawson, 2013; Standring et al., 2016). The ATN has been reported to arise as two roots within the ITF, forming a buttonhole to encircle the MMA before re-joining to form its main trunk (Ellis and Lawson, 2013; Standring et al., 2016). Some aural structures, the temporomandibular joint (TMJ), the posterior portion of the temple, and the parotid gland, are innervated by the ATN (Janis et al., 2010; Ellis and Lawson, 2013; Standring et al., 2016).

The MMA is the maxillary artery's largest branch and originates within the ITF as the third branch from the first segment of the maxillary artery (Joo et al., 2013; Standring et al., 2016). The MMA coursed cranially through the buttonhole of the ATN and entered the cranium via foramen spinosum, supplying the dura mater (Joo et al., 2013; Standring et al., 2016). The ITF may contain an accessory middle meningeal artery (aMMA), which arises from either the MMA or the maxillary artery, depending on whether the maxillary artery runs superficial or deep to the lateral pterygoid muscle (LPM) (Baumel and Beard, 1961; Joo et al., 2013; Standring et al., 2016; Bonasia et al., 2020).

While standard anatomical texts stipulates the usual morphology of the ATN and its relationship to the MMA, many authors have discovered variations in this regard (Gulekon et al., 2005; Chan et al., 2013; Thotakura et al., 2013; Bhardwaj et al., 2014; Dias et al., 2015; Komarnitki et al., 2015). 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 authors hereby confirm that every effort was made to comply with all local and international ethical guidelines and laws concerning the use of human cadaveric donors in anatomical research. 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. (2015), Komarnitki et al. (2015), and Loukas et al. (2019).

The cadavers were placed in a supine position. The cadavers were dissected using sharp and blunt dissection to expose the ITF and its contents.

Step 1. Two horizontal incisions were made using a scalpel – one slightly above and parallel to the superior border of the zygomatic arch and the other parallel to the inferior border of the mandible (Komarnitki et al., 2015) (Fig. 1). Next, one vertical incision was made anterior to the tragus of the ear to connect the horizontal incisions (Komarnitki et al., 2015) (Fig. 1). The skin was then reflected to reveal underlying structures. The superficial fascia, adipose, parotid glands and ducts were removed, along with the superficial temporal branch of the ATN.

Step 2. The zygomatic arch was cleaned and separated from the underlying temporalis muscle (Loukas et al., 2019). The masseter was cleaned and reflected inferiorly, exposing the mandible.

Step 3. Thereafter, using a bone saw, the zygomatic arch was cut at two places – anterior to the masseter muscle's origin and anterior to the articular tubercle of the TMJ – and removed (Komarnitki et al., 2015) (Fig. 2). The point of insertion of the temporalis muscle at the coronoid process was severed and reflected superiorly (Dias et al., 2015). A probe was then placed underneath the ramus of the mandible, at the

mandibular notch, pointing anteroinferiorly to protect the underlying IAN, LN, and their vessels (Loukas et al., 2019). The ramus of the mandible was first cut with a bone saw in two places – approximately 1cm below the condylar process and 5 to 7.5cm below the condylar process (Loukas et al., 2019) (Fig. 2). During the cutting process, careful attention was paid not to damage the ATN, which is located near the neck of the mandible. When using the bone saw, small cuts were made first not to damage the underlying nerves. Then, using a chisel, the remaining bones were severed.

Step 4. Soft tissues and adipose were cleaned and removed from the exposed lateral and medial pterygoid muscles (Loukas et al., 2019). Careful removal of the lateral pterygoid muscle using sharp dissection occurred, with precise attention placed on the maxillary artery and underlying nerves. The maxillary artery was reflected laterally as it obstructed proper visualization of the ATN and MMA.

Step 5. Tracing the IAN superiorly to the foramen ovale assisted in identifying the trunk of the CNV_3 (Loukas et al., 2019). The CNV_3 and its branches were cleaned in a cranial direction. 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.

Step 6. 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. Additionally, the presence of aMMA was recorded. The distance between the roots of the ATN was measured three times for accuracy using a digital vernier caliper and recorded. Other structures contained within the ATN roots were identified and documented if any. The descriptions and data were entered into a Microsoft Excel 2016 spreadsheet for analysis. The exposed ITF of individuals were photographed to facilitate further analyses of the ATN and MMA and their relationship.

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

RESULTS

1. Demographics

The individuals used in the study were of South African White and African descent. The individuals' ages ranged from 47 to 91 years. Fifty percent of the individuals were males, while the other half were females (Table 1).

2. Morphology of the ATN

The morphology of the ATN is shown in Table 2.

a. One-root ATN

Eight of the nine one-root ATN originated from the CNV_3, while the remaining one originated from the IAN (Table 3).

b. Two-root ATN

Seven out of 14 two-root individuals displayed both roots originating from the CNV_3 (Table 3). The remaining individuals showed the first root originating from the CNV_3 and the second from the IAN. All individuals with a two-root ATN had a V-shape formation, but the MMA was only found to pass through eight (Fig. 3).

c. Three-root ATN

Seven individuals had three-root ATN (Table 2). However, only three ATN were discovered with all roots originating from CNV_3. The first root of the remaining four ATN originated from CNV_3 and the two inferior roots from the IAN (Table 3). All individuals had a V-shape formation, similar to the two-root ATN. However, the MMA only passed through four V-shapes.

d. Four-root ATN

Only two individuals displayed four-root ATN with their first root from the CNV_3, and their third and fourth roots originating from the IAN (Table 3). However, in one individual, the second root originated from the CNV_3, while another originated from the IAN. Both ATN exhibited V-shaped formations, but

only one had the MMA passing through. The superior two roots joined together in the remaining individual, and the inferior two joined together, forming a V-shape through which the MMA passed.

3. Morphometry of the ATN

The average distances measured between the roots of the ATN are shown in Table 4. The mean length measured between the first and second roots of the ATN was found to be the largest (4.69mm±5.24), while the distance between the third and fourth roots was the smallest (2.67mm±2.06).

4. 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 5. However, it is noted that particular ATN were also related to the maxillary artery:

In a two-root ATN, the second root of the ATN was superficial to both the MMA and maxillary artery. Two ATN had their second roots deep to the maxillary artery and were, therefore, unrelated to the MMA. The second root of one ATN, which originated from CNV_3, split into a buttonhole. However, no vascular structures passed through it.

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

5. Course of the maxillary artery

The maxillary artery often coursed deep to the LPM in the studied sample (Table 2). Of the 19 deep-coursing arteries, the maxillary arteries coursed through a loop formed in the IAN in six individuals.

6. Presence of the aMMA

The aMMA was present in 14 individuals (43.75%) (Table 2). A double aMMA was found in one individual, which coursed superiorly, superficial to the ATN, and trifurcated (Fig. 4).

7. Origin of aMMA and its relationship to CNV_3

In a rare case, it was discovered that one individual exhibited two aMMA. Hence, 15 aMMA was encountered in this study. Seven aMMA originated directly from the MMA, while six arose from the maxillary artery. The individual exhibiting double aMMA originated from both the MMA and maxillary artery. The aMMA arising from the MMA passed superficial to CNV_3 in five individuals and deep in three. The aMMA originating from the maxillary artery, coursed deep to CNV_3 in four individuals. However, one aMMA was deep to the IAN and then crossed superficially to the LN. Another individual exhibited an aMMA coursing superficially to the LN.

The results of each individual, including demographics, are available from the corresponding author upon request. No statistically significant differences were found regarding laterality, sex, and age.

DISCUSSION

The ATN has been described to originate as two roots from the CNV_3, forming a buttonhole to enclose the MMA (Ellis and Lawson, 2013; Standring et al., 2016). However, many studies have discovered that the ATN can arise from as few as one to as many as five roots (Komarnitki et al., 2012; Quadros et al., 2016). The two-root ATN is the most prevalent in the American, Turkish, Polish, New Zealand, Indian, and Thai populations (Baumel et al., 1971; Gulekon et al., 2005; Komarnitki et al., 2012; Dias et al., 2015; Quadros et al., 2016; Chanasong et al., 2020). The two-root ATN was also the most common in the present study, which occurred in 43.75% of the South African population. Furthermore, the ATN can originate in the IAN and the CNV_3 (Komarnitki et al., 2012; Dias et al., 2015; Chanasong et al., 2020). This study demonstrated that the ATN can arise from the CNV_3 and the IAN, with the first root originating from the former and the inferior roots from the latter. Quadros et al. (2016) discovered that the IAN was a point of origin for all the ATN in the Indian population. In contrast, Komarnitki et

al. (2012), Dias et al. (2015), and Chanasong et al. (2020) found the IAN contributes to the main trunk of the ATN. In contrast, a one-root ATN in this study originated only from the IAN, which has not been previously documented. The IAN's contribution to the ATN could explain unexpected ATN neuralgia when anesthesia is administered to the IAN (Ngeow and Chai, 2009).

The average distance measured between the ATN roots was 4.42mm in the present study. These findings supported the results of Gulekon et al. (2005), who discovered a mean distance of 3.92mm. However, it is noted that the distance between the inferior roots appears to be larger than the distance between the first and second roots.

Previous research has described the ATN roots' relationship to the MMA as either superficial or deep to the artery (Baumel et al., 1971; Gulekon et al., 2005; Dias et al., 2015; Quadros et al., 2016). On the other hand, the present study included a description of the roots being anterior to the artery. The inferior roots in certain individuals were discovered to emerge from the CNV_3 and connected to the main trunk of the ATN anterior to the origin or course of the MMA. Similarly, this study demonstrated that the superior or first roots are usually superficial to the MMA, whereas inferior roots are deep. Concerning the relationship of the roots of the two-root ATN to the MMA, the present study corroborated with Baumel et al. (1971) and Gulekon et al. (2005); the upper or first root is superficial, while the lower or second root is deep to the MMA. 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 (Baumel et al., 1971). On the contrary, the first root in the Turkish population was superficial to the MMA, while the lower two were deep (Gulekon et al., 2005). Moreover, the Indian population showed one root being medial and two lateral to the MMA (Quadros et al., 2016). As a result, there is a great deal of variation in the relationship between the ATN roots and the MMA. Therefore, medical professionals should be aware of these variations when performing surgeries in the ITF.

In agreement with previous literary reports, the typical buttonhole formation was not discovered in the present South African population (Baumel et al., 1971; Komarnitki et al., 2012; Dias et al., 2015). However, the inferior root of a two-root ATN did form a buttonhole in this study, which is not the standard buttonhole formation around

the MMA described in anatomical literature (Standring et al., 2016). The most common interval formed by the roots of the ATN in this study was a V-shape, as noted in previous studies (Baumel et al., 1971; Komarnitki et al., 2012; Dias et al., 2015). In contrast to previous studies, the V-shape was found in 22/32 of the selected sample, but the MMA was only enclosed in 14 (63.64%). In the reports by Dias et al. (2015) and Chanasong et al. (2020), the MMA was enclosed in 52.00% and 69.86% of the individuals, respectively. Furthermore, Baumel et al. (1971) reported that the maxillary artery was closely related to the ATN in one individual. The maxillary artery was discovered to be looping over the inferior root of the ATN, dragging it down (Baumel et al., 1971). Although the current study found no such link between ATN and maxillary artery, it was noted that when the maxillary artery is deep to the LPM, it frequently encounters the ATN. In 8.24% of the American population, the maxillary artery was deep to the LPM (Baumel et al., 1971). In contrast to the American population, the deep course of the maxillary artery was found in 59.38% of South Africans (Baumel et al., 1971). These findings support previous research findings that the buttonhole is seldom present and that the MMA does not always pass through the ATN's V-shape (Baumel et al., 1971; Komarnitki et al., 2012; Dias et al., 2015). Furthermore, the standard superficial maxillary course is not typical in the South African population and may be found to course deep to the LPM, within the ITF.

Although Baumel and Beard (1961) concluded that the aMMA is almost always present, it was found in only 43.75% of the individuals in the present study. Similarly, Chanasong et al. (2020) discovered aMMA in 21.91% of their samples. The aMMA may also arise in equal parts from the MMA and the maxillary artery (Baumel and Beard, 1961). However, Chanasong et al. (2020) discovered that the aMMA arose more frequently from the MMA (75.00%). This study also found the aMMA frequently originated from the MMA (53.33%) in the South African population. Baumel and Beard (1961), however, discovered that the aMMA originated from the MMA in 47.95% of their sample. Moreover, Baumel and Beard (1961) proposed that the path of the maxillary artery in relation to the LPM determines the origin of the aMMA. When the maxillary artery is superficial to the LPM, the aMMA arises from the MMA. However, the aMMA arose from the maxillary artery when the maxillary artery courses deep to the LPM (Baumel and Beard, 1961), which was demonstrated in the current study.

Additionally, the relationship between the aMMA and CNV_3 has been previously documented (Baumel and Beard, 1961). However, the present study is the first to document this relationship since Baumel and Beard (1961).

Baumel and Beard (1961) discovered that the aMMA is frequently deep to the CNV_3. According to the findings of the current study, when the aMMA originated from the maxillary artery, it was commonly deep to the CNV_3. In contrast, when the aMMA originated from the MMA, it was commonly superficial to the CNV_3. However, on one occasion, the aMMA from the maxillary artery coursed deep to the IAN before crossing superficially to the LN. As a result, this study suggests that the relationship between the CNV_3 and the aMMA is influenced by the vessel's origin. The presence of an aMMA within a population should be considered when performing MMA embolization for the treatment of chronic subdural hematomas. Link et al. (2018) suggested that embolizing the distal branches of the MMA could be effective in the treatment of chronic subdural hematomas. However, since the aMMA supplies the trigeminal ganglion, embolization of the artery should be carefully and critically considered to avoid injury to the CNV.

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.

CONCLUSION

This study examined the relationship between the MMA and the ATN in a South African population. The study's findings indicated variations in the morphology of the ATN and its relationship to the MMA, which are similar to those highlighted in previous studies. The relationship between the ATN and MMA in the present study depicts that although there are variations commonly present in samples, these variations are not concisely documented in standard anatomical literature. Communication between the ATN and the IAN may explain the complications of IAN nerve blocks. During a perineural tumor spread in the ITF, the contribution of the IAN to the ATN should be considered. When performing endovascular MMA embolization, the incidence of an aMMA within a population should be considered as this may cause complications. Furthermore, this study adds pivotal information on the contents of the ITF in a South African population, which may help surgeons accurately identify neurovasculature within the ITF.

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 utilize a bigger sample size to determine if there are significant differences in laterality, age, sex, and population groups.

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

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.

6. AUTHOR CONTRIBUTIONS

S.M. – concept/design, acquisition of data, data analysis/interpretation, drafting of the manuscript.

S.I. – concept/design, critical revision of the manuscript, and approval of the article.

P.P – concept/design, critical revision of the manuscript, and approval of the article.

7. REFERENCES

BAUMEL, J. J. & BEARD, D. Y. 1961. The accessory meningeal artery of man. *Journal of anatomy,* 95**,** 386-402.

BAUMEL, J. J., VANDERHEIDEN, J. P. & MCELENNEY, J. E. 1971. The auriculotemporal nerve of man. *Am J Anat,* 130**,** 431-40.

BHARDWAJ, N., SAHNI, P., SINGHVI, A., NAYAK, M. & TIWARI, V. 2014. Case Report. Anomalous Bilateral Communication between the Inferior Alveolar Nerve and the Auriculotemporal Nerve: A Rare Variation. *Malaysian Journal of Medical Sciences,* 21**,** 71-74.

BONASIA, S., SMAJDA, S., CICCIO, G. & ROBERT, T. 2020. Middle Meningeal Artery: Anatomy and Variations. *American Journal of Neuroradiology,* 41**,** 1777.

CHAN, M., DMYTRIW, A. A., BARTLETT, E. & EUGENE, Y. 2013. Imaging of auriculotemporal nerve perineural spread. *Ecancermedicalscience,* 7**,** 1-5.

CHANASONG, R., KITI-NGOEN, K., KHAODAENG, C., SAKULSAK, N. & CHOOMPOO, N. 2020. Anatomical Variation of the Auriculotemporal Nerve in Thai Cadavers. *International Journal of Morphology,* 38**,** 1657-1661.

DIAS, G., KOH, J. & CORNWALL, J. 2015. The origin of the auriculotemporal nerve and its relationship to the middle meningeal artery. *Anatomical Science International,* 90**,** 216-221.

ELLIS, H. & LAWSON, A. 2013. The Cranial Nerves. *Anatomy for Anaesthetists.* 9th ed.: Wiley-Blackwell.

GULEKON, N., ANIL, A., POYRAZ, A., PEKER, T., TURGUT, H. B. & KARAKOSE, M. 2005. Variations in the anatomy of the auriculotemporal nerve. *Clin Anat,* 18**,** 15-22.

JANIS, J. E., HATEF, D. A., DUCIC, I., AHMAD, J., WONG, C., HOXWORTH, R. E. & OSBORN, T. 2010. Anatomy of the auriculotemporal nerve: variations in its relationship to the superficial temporal artery and implications for the treatment of migraine headaches. *Plast Reconstr Surg,* 125**,** 1422-1428.

JOO, W., FUNAKI, T., YOSHIOKA, F. & RHOTON, A. L., JR. 2013. Microsurgical anatomy of the infratemporal fossa. *Clinical anatomy (New York, N.Y.),* 26**,** 455-469.

KIM, H. K., LEE, Y. S., KHO, H. S., YUM, K. W. & CHUNG, S. C. 2003. Facial and glossal distribution of anaesthesia after inferior alveolar nerve block. *Journal of Oral Rehabilitation,* 30**,** 189-193.

KOMARNITKI, I., ANDRZEJCZAK-SOBOCIŃSKA, A., TOMCZYK, J., DESZCZYŃSKA, K. & CISZEK, B. 2012. Clinical anatomy of the auriculotemporal nerve in the area of the infratemporal fossa. *Folia Morphol (Warsz),* 71**,** 187-93.

KOMARNITKI, I., TOMCZYK, J., CISZEK, B. & ZALEWSKA, M. 2015. Proposed Classification of Auriculotemporal Nerve, Based on the Root System. *PLoS ONE,* 10**,** 1-17.

LINK, T. W., RAPOPORT, B. I., PAINE, S. M., KAMEL, H. & KNOPMAN, J. 2018. Middle meningeal artery embolization for chronic subdural hematoma: Endovascular technique and radiographic findings.

Interventional neuroradiology : journal of peritherapeutic neuroradiology, surgical procedures and related neurosciences, 24**,** 455-462.

LOUKAS, M., BENNINGER, B. & TUBBS, R. S. 2019. *Gray's Clinical Photographic Dissector of the Human Body, 2 Edition- South Asia Edition-E-Book*, Elsevier Health Sciences.

NGEOW, W. C. & CHAI, W. L. 2009. Numbness of the ear following inferior alveolar nerve block: the forgotten complication. *Br Dent J,* 207**,** 19-21.

QUADROS, L. S., JAISON, J., BHAT, N., PRASANNA, L. C., BHAT, K. M. R. & KALTHUR, S. G. 2016. Auriculotemporal Nerve – A Study on its Roots. *Online Journal of Health & Allied Sciences,* 15.

SCHMALFUSS, I. M., TART, R. P., MUKHERJI, S. & MANCUSO, A. A. 2002. Perineural tumor spread along the auriculotemporal nerve. *AJNR Am J Neuroradiol,* 23**,** 303-11.

STANDRING, S., ANAND, N., BIRCH, R., COLLINS, P., CROSSMAN, A. R., GLEESON, M., JAWAHEER, G., SMITH, A., SPRATT, J. D., STRINGER, M. D., TUBBS, R. S., TUNSTALL, R., WEIN, A. J. & WIGLEY, C. B. 2016. *Gray's Anatomy: the anatomical basis of clinical practice,* Edinburgh, Elsevier.

THOMPSON, J. D., AVEY, G. D., WIELAND, A. M., HARARI, P. M., GLAZER, T. A., MCCULLOCH, T. M. & HARTIG, G. K. 2019. Auriculotemporal Nerve Involvement in Parotid Bed Malignancy. *Annals of Otology, Rhinology & Laryngology,* 128**,** 647-653.

THOTAKURA, B., SHARMILA, S., VAITHIANATHAN, G. & SUBRAMANIAN, A. 2013. Variations in the posterior division branches of the mandibular nerve in human cadavers. *Singapore medical journal,* 54**,** 149-51.

TIWARI, R. 1998. Surgical landmarks of the infratemporal fossa. *Journal of Cranio-Maxillofacial Surgery,* 26**,** 84-86.

VAN LIEROP, A. C. & FAGAN, J. J. 2007. Parotidectomy in Cape Town--a review of pathology and management. *S Afr J Surg,* 45**,** 96-8, 100, 102-3.

WHO. 2020. *Salivary glands* [Online]. World Health Oragnization - International Agency for Research on Cancer - The Global Cancer Observatory. Available: https://gco.iarc.fr/today/data/factsheets/cancers/2-Salivary-glands-fact-sheet.pdf. [Accessed 10 June 2021].

8. DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

9. TABLES

Table 1 Ethnicity, sex, and age of the studied South African population (n=32)

Ethnicity		Sex		Age (years) Mean±SD
White (%)	African (%)	Male (%)	Female (%)	72.4±11.9
28 (87.50%)	4 (12.50%)	18 (50.00%)	18 (50.00%)	

SD standard deviation

Table 2 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

411 **Table 3** The origin of the roots from either the CNV_3 or the IAN in the one-, two-, three-, and four-root ATN

	One-root ATN		Two-root ATN		Three-root ATN		Four-root ATN	
Point of origin of ATN roots	CNV_3	IAN	CNV_3	IAN	CNV_3	IAN	CNV_3	IAN
Origin of first root	8	1	14	-	7	-	2	-
Origin of second root	-	-	7	7	3	4	1	1
Origin of third root	-	-	-	-	3	4	-	2
Origin of fourth root	-	-	-	-	-	-	-	2
Total	8	1	21	7	13	8	3	5

412 *ATN* auriculotemporal nerve; *CNV_3* mandibular nerve; *IAN* inferior alveolar nerve

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Table 4 Mean distances measured between the first and second, second and third, and third and fourth roots of the ATN (mm)

	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

ATN auriculotemporal nerve; *SD* standard deviation

Table 5 Relationship between roots of the one-, two-, three-, and four-root ATN and the MMA in dissected infratemporal fossae

	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

ATN auriculotemporal nerve; *MMA* middle meningeal artery

10. FIGURE LEGENDS

Fig. 1 Skin incisions made on the cadaver using a scalpel. Red lines indicate the incisions made on the cadaver. Line **AB** is the first horizontal incision parallel to the zygomatic arch. Line **CD** is the second horizontal incision parallel to the inferior border of the mandible. Line **BD** is the vertical incision made anterior to the ear, connecting the two horizontal incisions

Fig. 2 Cuts made on the zygomatic arch and mandibular ramus using a bone saw. Cuts made on the zygomatic arch – anterior to the origin of the masseter muscle and anterior to the articular tubercle of the temporomandibular joint (yellow dashed line). Cuts made on the mandibular ramus – approximately 1cm below the condylar process (blue dashed line) and 5 to 7.5cm below the condylar process (green dashed line)

Fig. 3 A two-root ATN and MMA within the ITF. 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, *ATN* auriculotemporal nerve, *CNV_3* mandibular nerve, *MMA* middle meningeal artery, *LN* lingual nerve, *IAN* inferior alveolar nerve

Fig. 4 Schematic representation of the three-root ATN variant. The second root bifurcated – upper part joined first root and lower part joined third root. MMA passed through V-shape created between the first and second roots. Maxillary artery was deep to the LPM and coursed deep to the IAN and LN. Double aMMA was found in this individual - one originated from the MMA and coursed superficially to the ATN and trifurcated, and another originated from the maxillary artery, coursed deep to the IAN and crossed superficial to the LN. *ATN* auriculotemporal nerve, *MMA* middle meningeal artery, *MA* maxillary artery, *aMMA* accessory middle meningeal artery, *CNV_3* mandibular nerve, *IAN* inferior alveolar nerve, *LN* lingual nerve

Fig. 1

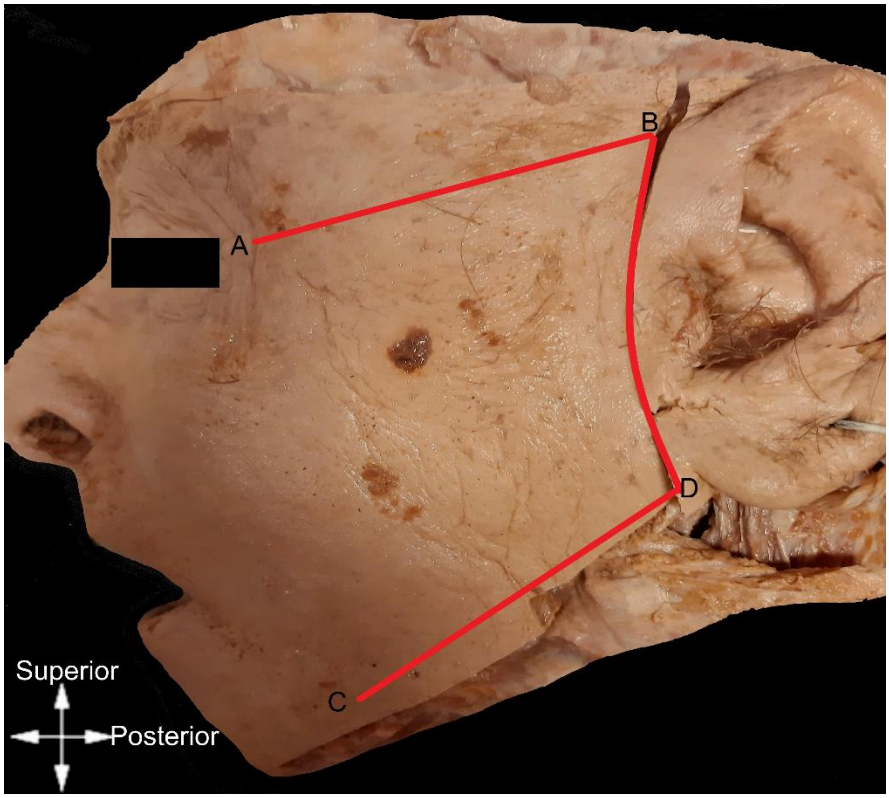

B
A
D
C
Superior
Posterior

Fig. 2

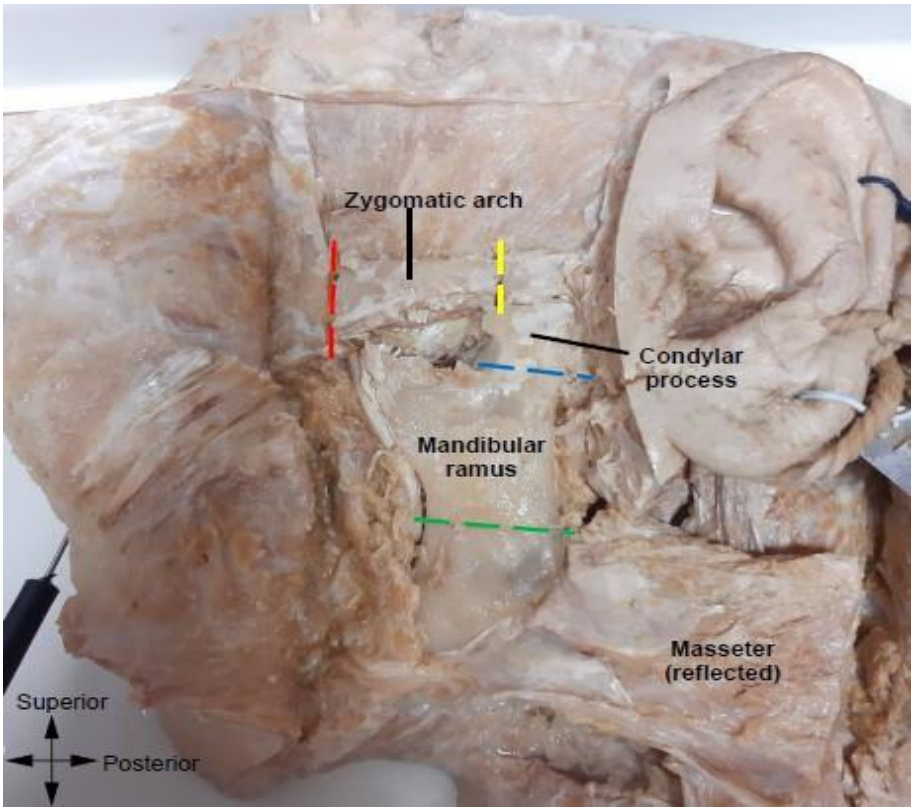

Zygomatic arch
Condylar process
Mandibular ramus
Masseter (reflected)
Superior
Posterior

Fig. 3

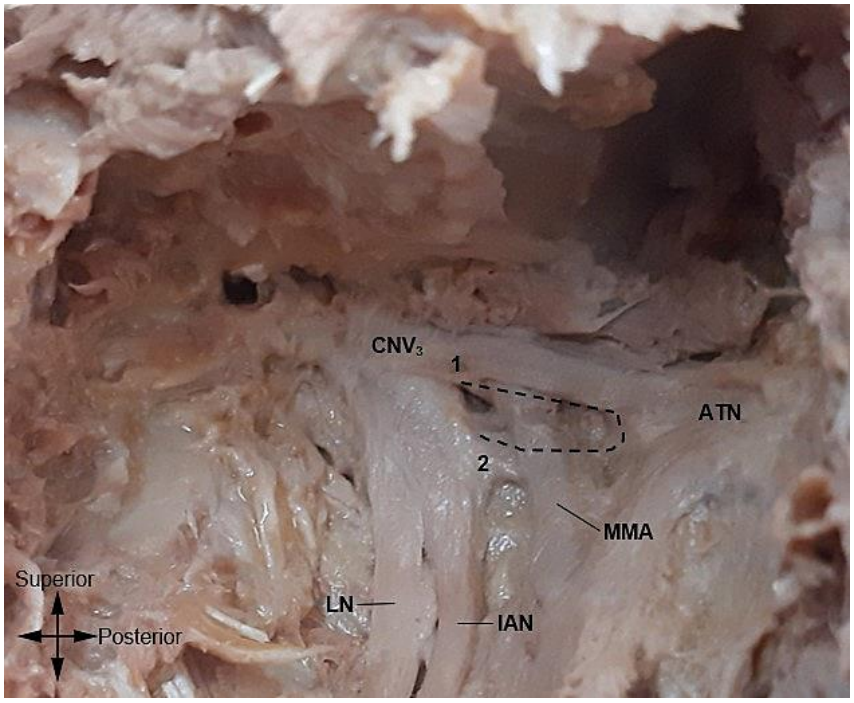
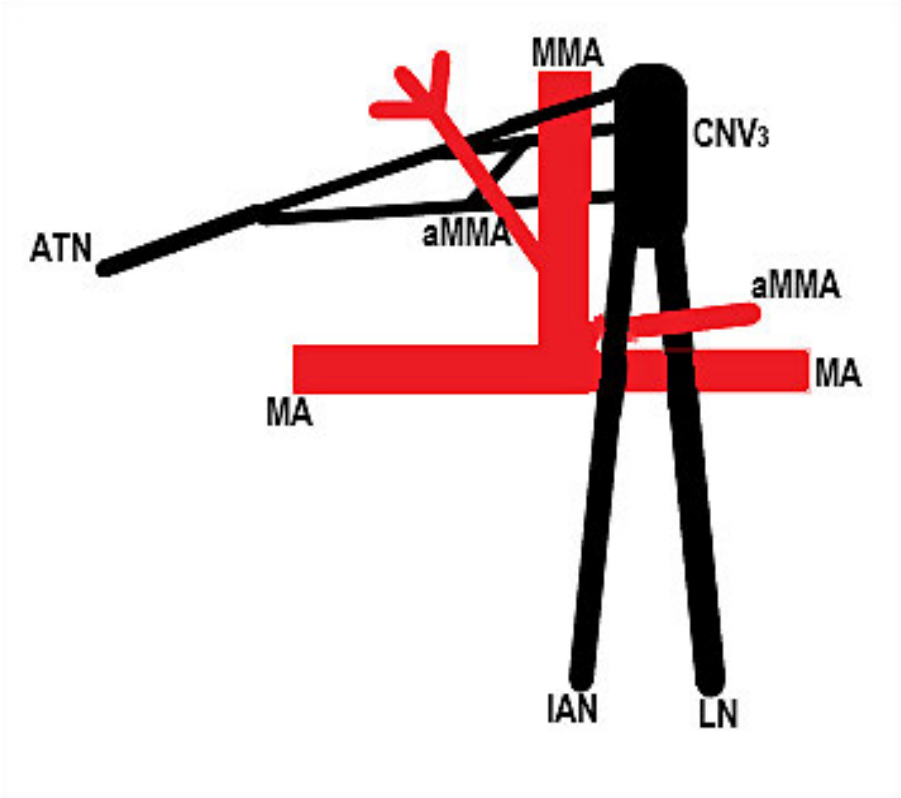

CNV3
1
2
ATN
MMA
Superior
Posterior
LN
IAN

Fig. 4


MMA
CNV3
ATN
aMMA
aMMA
MA
MA
IAN
LN

CHAPTER 3

3.1 Synthesis

This study investigated the relationship between the ATN and the MMA by documenting the morphology and morphometry of the ATN, the anatomy of the MMA, and their anatomical variations. The roots of the ATN were deep or superficial to the MMA or were shown to enclose the MMA in a V shape. The relationship between the ATN and adjacent vascular structures is crucial during surgery within the infratemporal fossa, such as the resection of a perineural tumour.

The boundaries of the infratemporal fossa in the present study compared favourably with Joo et al. (2013). The anterior boundary was formed by the maxillary sinus, the posterior boundary by the temporal bone and constituting the styloid process, the lateral boundary by the ramus of the mandible, and the medial boundary by the lateral pterygoid plate of the sphenoid bone. The anatomical borders of the infratemporal fossa may provide a reference for the anatomical course of its neurovasculature and are crucial in performing surgeries within this region.

Within the selected South African cohort, the morphology of the ATN was variable, *viz.*, one to four roots, which corroborated with the findings described by Baumel et al. (1971), Gulekon et al. (2005), Dias et al. (2015) and Chanasong et al. (2020) in the American, Turkish, New Zealand and Thai populations, respectively. However, in the Polish and Indian populations, the ATN originated from as many as five roots (Komarnitki et al., 2012; Quadros et al., 2016). Hence, more than two roots forming the ATN may imply that there would also be several nerve loops within the infratemporal fossa as the roots join, which may pose additional complications during surgeries to the infratemporal fossa.

The morphometric distance between roots of the ATN in the one-, two-, three-, and four-root variations depicted that the superior roots originated further away from each other than the inferior roots. This emphasised that the roots of the ATN do not originate close to each other or at the same point from the mandibular nerve. The distance between roots is imperative in determining the level of origin of the roots of the ATN (Baumel et al., 1971). It was noted in the present study that the ATN originated at different points on the mandibular nerve or inferior alveolar nerve and did not split to enclose the MMA. Baumel et al. (1971) found that the distance between the two roots of the ATN was 3.69mm, and Gulekon et al. (2005) also recorded an average distance of 4.12mm, while this study found the distance to be 4.69mm. These findings suggest that the roots of the ATN originate closer to each other in the South African and Turkish populations than in the American population, which further implies that the distance between roots may be influenced by ethnicity.

In corroboration with previous literary reports, the inferior alveolar nerve contributed to the formation of the ATN, whereby it was found that when the ATN was formed by more than one root, the inferior roots often arose from the inferior alveolar nerve (Komarnitki et al., 2012; Dias et al., 2015; Chanasong et al., 2020). The communication between the inferior alveolar nerve and the ATN may impact the effectiveness of anaesthesia or neuralgia of the inferior alveolar nerve and the distribution of the ATN (Bhardwaj et al., 2014). Additionally, nerves communicating with the ATN may provide additional or alternative pathways for the spread of malignant tumours since the ATN forms a pathway for perineural tumour spread (Schmalfuss et al., 2002). The involvement of other nerves further decreases the survival rate resulting from a tumour within the infratemporal fossa (Thompson et al., 2019). Therefore, the communication between the ATN and the inferior alveolar should be considered when assessing a perineural tumour, as an abnormal mass may affect areas innervated by the inferior alveolar nerve (Schmalfuss et al., 2002).

The intervals created by the ATN are crucial in assessing its relationship to the MMA. Regarding morphological formations of ATN and its relationship with MMA, the common buttonhole formation was not encountered in this study; instead, the ATN had V-shape formations in the majority (68.75%) of the dissected individuals. Baumel et al. (1971) also discovered V-shape formations in 83.87% and Dias et al. (2015) in 52.00% of individuals. Furthermore, it was found that a small portion of MMA (n=13) passed through this formation which agreed with various authors that stated that the MMA does not commonly pass through an interval formed by the ATN (Baumel et al., 1971; Gulekon et al., 2005; Komarnitki et al., 2012). Compression of the MMA may result due to morphological formation of the ATN; therefore, knowledge of this anatomical position is vital for surgeons.

Standard anatomical text described the maxillary artery as having three parts relating to the structures it courses near to in its superficial path (Standring et al., 2016). However, the three parts are not distinct in the deep course of the maxillary artery. The present study documented that the maxillary artery was frequently located deep to the lateral pterygoid muscle; however, further description of the deep course of the maxillary is necessary to identify its different parts correctly. Additionally, Standring et al. (2016) found that the maxillary artery passes through a loop created in the inferior alveolar nerve in four percent of the global population. However, the maxillary artery in the present study passed through a loop of the inferior alveolar nerve in six of the 19 (31.58%) deep-coursing maxillary arteries. Although the anatomy of the maxillary artery is typically described in its superficial course, a more detailed understanding of its deep course is necessary during surgeries within the infratemporal fossa to avoid unnecessary iatrogenic injuries (Fang et al., 2019).

The accessory middle meningeal artery was present in 43.75% of this select South African cohort, corroborating with the study by Chanasong et al. (2020). The variable incidence of the accessory middle meningeal artery in the American (96.00%) and the lower incidence in the South African (43.75%) and Thai (21.91%) populations suggested that ethnicity may influence the incidence of the accessory middle meningeal artery. Moreover, a double accessory middle meningeal artery was discovered in one South African individual, supporting the study by Baumel and Beard (1961), who discovered multiple accessory arteries in an individual. Knowledge of the incidence and occurrence of the accessory middle meningeal artery and multiple arteries in an individual may be crucial in surgeries of the infratemporal fossa and the spread of tumours along the ATN due to the close relationship between the nerves and vessels within the infratemporal fossa. The present study's findings disagree with Uysal et al. (2011), who stated that the course of the maxillary artery in relation to the lateral pterygoid muscle does not influence the origin of the accessory middle meningeal artery. Therefore, the selected samples in this study confirmed that when the maxillary artery is deep to the lateral pterygoid muscle, the accessory middle meningeal artery originated from the maxillary artery. However, further investigation of the accessory middle meningeal arteries and multiple arteries present is required to accurately determine the incidence of this vascular structure within the infratemporal fossa and the relationship between the course of the maxillary artery and the point of origin of the accessory middle meningeal artery.

3.2 Conclusion

The present study's findings provided novel information regarding the morphology and morphometry of the ATN and MMA within a South African population, which has not been previously documented in previous literary reports. This study demonstrated that the morphology of the ATN and the incidence of the accessory middle meningeal artery may be affected by ethnicity. The findings of this study further revealed the importance of understanding the contents of the infratemporal fossa, as a tumour spread along the ATN may cause damage to the vasculature within this region. Additionally, the contribution of the inferior alveolar nerve to the ATN is pivotal in perineural tumour spreads along the ATN, as this may impede the function of the inferior alveolar nerve. Consequently, these anatomical findings may provide the basis for the anatomy of the ATN and its relationship to the MMA in South Africans and may further provide insight into variations present in the neurovasculature within the infratemporal fossa.

3.3 Recommendations

Future studies should investigate the morphology of the ATN and MMA and their variations in other populations. Researchers should examine ethnic differences that may exist in the morphology of the ATN, the relationship between the ATN and MMA, and any variations. Possible morphological differences should also be explored between age groups, sexes, and laterality. Future studies may benefit from using a larger sample size than the present and previous studies. The sample size of the present study was smaller than that of previous studies due to the limitations of this study. However, the present study used the same sample size as Gulekon et al. (2005). Furthermore, the relationship between the ATN and MMA was mainly investigated in adult samples. Future research may provide additional insight into the relationship between the ATN and MMA and the presence of variations in foetal individuals.

3.4 Limitations

The ethnicities of the samples were not equally distributed in the present study. Twenty-eight individuals were of South African white descent, and the rest were South African black. In addition, the sample was of an older cohort. Moreover, differences in ethnicities, sexes, ages, and laterality could not be determined. The aforementioned factors could not be determined due to the limited sample size available at the department during the data collection period. Previous use of some cadaveric material resulted in damage to the infratemporal fossa region and, hence, could not be utilised in this study. Furthermore, due to the COVID-19 pandemic, the number of available cadavers to be prosected for research and teaching purposes has severely decreased, hence, the small sample size. Statistical analysis did not present significant differences in ethnicity, age, sex, or laterality due to the small sample size. However, the possibility of differences between these factors should not be entirely eliminated. Hence, studies with larger sample sizes are recommended.

3.5 References

ALLEN, W. E., KIER, E. L. & ROTHMAN, S. L. 1973. The maxillary artery: normal arteriographic anatomy. Am J Roentgenol Radium Ther Nucl Med, 118, 517-27.

ALRADDADI, A. 2021. Literature Review of Anatomical Variations: Clinical Significance, Identification Approach, and Teaching Strategies. Cureus, 13, e14451-e14451.

BAUMEL, J. J. & BEARD, D. Y. 1961. The accessory meningeal artery of man. Journal of anatomy, 95, 386-402.

BAUMEL, J. J., VANDERHEIDEN, J. P. & MCELENNEY, J. E. 1971. The auriculotemporal nerve of man. Am J Anat, 130, 431-40.

BHARDWAJ, N., SAHNI, P., SINGHVI, A., NAYAK, M. & TIWARI, V. 2014. Case Report. Anomalous Bilateral Communication between the Inferior Alveolar Nerve and the Auriculotemporal Nerve: A Rare Variation. Malaysian Journal of Medical Sciences, 21, 71-74.

BONASIA, S., SMAJDA, S., CICCIO, G. & ROBERT, T. 2020. Middle Meningeal Artery: Anatomy and Variations. American Journal of Neuroradiology, 41, 1777.

BOZKURT, G., TURRI-ZANONI, M., RUSSO, F., ELHASSAN, H. A., CASTELNUOVO, P. & BATTAGLIA, P. 2019. Ultrasonic Scalpel-Assisted Endoscopic Endonasal Surgery of Infratemporal Fossa: Our First Impressions. World Neurosurg, 123, 23-28.

CAHILL, D. R. & LEONARD, R. J. 1999. Missteps and masquerade in American medical academe: Clinical anatomists call for action. Wiley Online Library.

CHAN, M., DMYTRIW, A. A., BARTLETT, E. & EUGENE, Y. 2013. Imaging of auriculotemporal nerve perineural spread. Ecancermedicalscience, 7, 1-5.

CHANASONG, R., KITI-NGOEN, K., KHAODAENG, C., SAKULSAK, N. & CHOOMPOO, N. 2020. Anatomical Variation of the Auriculotemporal Nerve in Thai Cadavers. International Journal of Morphology, 38, 1657-1661.

DIAS, G., KOH, J. & CORNWALL, J. 2015. The origin of the auriculotemporal nerve and its relationship to the middle meningeal artery. Anatomical Science International, 90, 216-221.

DILENGE, D. & GÉRAUD, G. 1975. Accessory Meningeal Artery. Acta Radiologica. Diagnosis, 16, 63-69.

ELLIS, H. & LAWSON, A. 2013. The Cranial Nerves. Anatomy for Anaesthetists. 9th ed.: Wiley-Blackwell.

FANG, Y., WU, H., ZHAO, W. & CHENG, L. 2019. Endoscopic transvestibular anatomy of the infratemporal fossa and upper parapharyngeal spaces for clinical surgery: a cadaver study. European Archives of Oto-Rhino-Laryngology, 276, 1799-1807.

GULEKON, N., ANIL, A., POYRAZ, A., PEKER, T., TURGUT, H. B. & KARAKOSE, M. 2005. Variations in the anatomy of the auriculotemporal nerve. Clin Anat, 18, 15-22.

HITOTSUMATSU, T. & RHOTON, A. L., JR. 2000. Unilateral upper and lower subtotal maxillectomy approaches to the cranial base: microsurgical anatomy. Neurosurgery, 46, 1416-52; discussion 1452-3.

JANIS, J. E., HATEF, D. A., DUCIC, I., AHMAD, J., WONG, C., HOXWORTH, R. E. & OSBORN, T. 2010. Anatomy of the auriculotemporal nerve: variations in its relationship to the superficial temporal artery and implications for the treatment of migraine headaches. Plast Reconstr Surg, 125, 1422-1428.

JOO, W., FUNAKI, T., YOSHIOKA, F. & RHOTON, A. L., JR. 2013. Microsurgical anatomy of the infratemporal fossa. Clinical anatomy (New York, N.Y.), 26, 455-469.

KALRA, S., THAMKE, S. & KHANDELWAL, A. 2014. An undocumented variation involving auriculotemporal nerve, inferior alveolar nerve and middle meningeal artery. Int J Res Med Sci, 2, 1720-2.

KIM, H. K., LEE, Y. S., KHO, H. S., YUM, K. W. & CHUNG, S. C. 2003. Facial and glossal distribution of anaesthesia after inferior alveolar nerve block. Journal of Oral Rehabilitation, 30, 189-193.

KOMARNITKI, I., ANDRZEJCZAK-SOBOCIŃSKA, A., TOMCZYK, J., DESZCZYŃSKA, K. & CISZEK, B. 2012. Clinical anatomy of the auriculotemporal nerve in the area of the infratemporal fossa. Folia Morphol (Warsz), 71, 187-93.

KOMARNITKI, I., TOMCZYK, J., CISZEK, B. & ZALEWSKA, M. 2015. Proposed Classification of Auriculotemporal Nerve, Based on the Root System. PLoS ONE, 10, 1-17.

KURUVILLA, A., AGUWA, A. N., LEE, A. W. & XAVIER, A. R. 2011. Anomalous Origin of the Middle Meningeal Artery from the Posterior Inferior Cerebellar Artery. Journal of Neuroimaging, 21, 269-272.

LOUGHNER, B. A., LARKIN, L. H. & MAHAN, P. E. 1990. Nerve entrapment in the lateral pterygoid muscle. Oral Surg Oral Med Oral Pathol, 69, 299-306.

LOW, F. N. 1946. An anomalous middle meningeal artery. The Anatomical Record, 95, 347-351.

MAEDA, S., AIZAWA, Y., KUMAKI, K. & KAGEYAMA, I. 2012. Variations in the course of the maxillary artery in Japanese adults. Anatomical Science International, 87, 187-194.

NALLAGATLA, S., KARUPPAN, M., MUNINARAYANASWAMY, G. & HOLAVANAHALLI, K. 2015. Communicating root of auriculotemporal nerve with inferior alveolar nerve-looping around accessory meningeal artery. International Journal of Research in Medical Sciences, 3, 626.

PIAGKOU, M., DEMESTICHA, T., PIAGKOS, G., ANDROUTSOS, G. & SKANDALAKIS, P. 2011a. Mandibular nerve entrapment in the infratemporal fossa. Surgical and radiologic anatomy : SRA, 33, 291-9.

PIAGKOU, M., DEMESTICHA, T., SKANDALAKIS, P. & JOHNSON, E. O. 2011b. Functional anatomy of the mandibular nerve: Consequences of nerve injury and entrapment. Clinical Anatomy, 24, 143-150.

QUADROS, L. S., JAISON, J., BHAT, N., PRASANNA, L. C., BHAT, K. M. R. & KALTHUR, S. G. 2016. Auriculotemporal Nerve – A Study on its Roots. Online Journal of Health & Allied Sciences, 15.

ROMANO, N., FEDERICI, M. & CASTALDI, A. 2019. Imaging of cranial nerves: a pictorial overview. Insights into Imaging, 10, 33.

ROYLE, G. & MOTSON, R. 1973. An anomalous origin of the middle meningeal artery. Journal of Neurology, Neurosurgery & Psychiatry, 36, 874.

SCHMALFUSS, I. M., TART, R. P., MUKHERJI, S. & MANCUSO, A. A. 2002. Perineural tumor spread along the auriculotemporal nerve. AJNR Am J Neuroradiol, 23, 303-11.

SHAH, Q. A. & HURST, R. W. 2007. Anomalous Origin of the Middle Meningeal Artery from the Basilar Artery: A Case Report. Journal of Neuroimaging, 17, 261-263.

SOMAYAJI, S. K., ACHARYA SR FAU - MOHANDAS, K. G., MOHANDAS KG FAU - VENKATARAMANA, V. & VENKATARAMANA, V. 2012. Anatomy and clinical applications of the mandibular nerve. Bratisl Lek Listy, 113, 431-440.

SONI, S., RATH, G., SURI, R. & VOLLALA, V. R. 2009. Unusual organization of auriculotemporal nerve and its clinical implications. Journal of oral and maxillofacial surgery, 67, 448-450.

STANDRING, S., ANAND, N., BIRCH, R., COLLINS, P., CROSSMAN, A. R., GLEESON, M., JAWAHEER, G., SMITH, A., SPRATT, J. D., STRINGER, M. D., TUBBS, R. S., TUNSTALL, R., WEIN, A. J. & WIGLEY, C. B. 2016. Gray's Anatomy: the anatomical basis of clinical practice, Edinburgh, Elsevier.

THOMPSON, J. D., AVEY, G. D., WIELAND, A. M., HARARI, P. M., GLAZER, T. A., MCCULLOCH, T. M. & HARTIG, G. K. 2019. Auriculotemporal Nerve Involvement in Parotid Bed Malignancy. Annals of Otology, Rhinology & Laryngology, 128, 647-653.

THOTAKURA, B., SHARMILA, S., VAITHIANATHAN, G. & SUBRAMANIAN, A. 2013. Variations in the posterior division branches of the mandibular nerve in human cadavers. Singapore medical journal, 54, 149-51.

TIWARI, R. 1998. Surgical landmarks of the infratemporal fossa. Journal of Cranio-Maxillofacial Surgery, 26, 84-86.

UYSAL, I. I., BÜYÜKMUMCU, M., ÜNVER DOĞAN, N., YıLMAZ, M. T., ŞEKER, M. & ZIYLAN, T. 2011. Clinical significance of maxillary artery and its branches: a cadaver study and review of the literature. International Journal of Morphology, 29, 1274-1281.

3.6 Appendix A: Ethics Approval

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

10 September 2021

Miss Sherelle Moodley (217004886)
School of Lab Med & Medical Sc
Westville

Dear Miss Moodley,

Protocol reference number: BREC/00002919/2021
Project title: The relationship between the auriculotemporal nerve and middle meningeal artery in a South African Population.
Degree: MMedSc

EXPEDITED APPLICATION: APPROVAL LETTER

A sub-committee of the Biomedical Research Ethics Committee has considered and noted your application.

The conditions have been met and the study is given full ethics approval and may begin as from 10 September 2021. Please ensure that outstanding site permissions are obtained and forwarded to BREC for approval before commencing research at a site.

This approval is subject to national and UKZN lockdown regulations, see (http://research.ukzn.ac.za/Libraries/BREC/BREC_Amended_Lockdown_Level_3_Guidelines.sflb.ashx). Based on feedback from some sites, we urge PIs to show sensitivity and exercise appropriate consideration at sites where personnel and service users appear stressed or overloaded.

This approval is valid for one year from 10 September 2021. To ensure uninterrupted approval of this study beyond the approval expiry date, an application for recertification must be submitted to BREC on the appropriate BREC form 2-3 months before the expiry date.

Any amendments to this study, unless urgently required to ensure safety of participants, must be approved by BREC prior to implementation.

Your acceptance of this approval denotes your compliance with South African National Research Ethics Guidelines (2015), South African National Good Clinical Practice Guidelines (2020) (if applicable) and with UKZN BREC ethics requirements as contained in the UKZN BREC Terms of Reference and Standard Operating Procedures, all available at http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx.

BREC is registered with the South African National Health Research Ethics Council (REC-290408-009). BREC has US Office for Human Research Protections (OHRP) Federal-wide Assurance (FWA 678).

The sub-committee's decision will be noted by a full Committee at its next meeting taking place on 12 October 2021.

Yours sincerely,

Prof D Wassenaar
Chair: Biomedical Research Ethics Committee

Biomedical Research Ethics Committee
Chair: Professor D R Wassenaar
UKZN Research Ethics Office Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Email: BREC@ukzn.ac.za
Website: http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx

3.7 Appendix B: College of Health Science Guidelines

GUIDELINES FOR PRESENTATION OF MASTERS AND PHD DISSERTATIONS/THESES BY RESEARCH

1. Purpose

The purpose of this document is to provide guidance to students and supervisors on how to prepare a dissertation/thesis for Masters by Research and PhD degrees using the manuscript or publication format..

2. Introduction

These guidelines must be read together with the College of Health Sciences (CHS) Handbook as well as the Jacobs documents on examination policies and procedures for PhD degrees. The rules on thesis format are based on modification of point 1 of the definition of terms section in the Jacobs document. In this section a thesis is defined as *"the supervised research component of all PhD degrees, whether by supervised research only, or coursework and research, or by papers that are either published or in manuscript form (the supervised research component of the PhD degree by paper(s) comprises the introduction, literature review, account of the methodology, selection of manuscripts, and conclusion)."* A dissertation is defined as "*the supervised research component of all Masters degrees, whether by supervised research only, or coursework and research, or by papers that are either published or in manuscript form (the supervised research component of the Masters degree by paper(s) comprises the introduction, literature review, account of the methodology, selection of manuscripts, and conclusion*)."

2.1 PhD thesis

In the CHS Handbook the rules for a PhD thesis are not in one place; they are stated in DR8 a i & ii, DR9 c and CHS 16. DR8 a i & ii and direct that a thesis be presented in the standard format together with one published paper or an unpublished manuscript that has been submitted to an accredited journal, arising from the doctoral research. CHS16 (thesis by publications states that the thesis may comprise of at least three published papers or in press in accredited journals; such papers must have the student as the prime author. The same CHS16 provides for a thesis by manuscripts that may have at least 3 papers with the student as the prime author that have not yet been published but are in the form of manuscripts; at least two of such papers must constitute original research. In both cases (thesis by publications and manuscripts), there must be introductory and concluding integrative material sections.

The standard type thesis is being phased out in many African countries in favour of the other options that originate from the Scandinavian countries. While this format ensures that all details of the work done for the doctoral degree are captured and thoroughly interrogated, they often remain as grey literature which is mainly useful to other students, usually within the same university, although with digitization of theses, such work may become more accessible beyond the source university. Apart from the risk of losing good work because of it not being on the public domain, as students rarely publish such work after graduating, this approach denies the college additional productivity units (PUs) emanating from publications.

The thesis by publication encourages students to publish key aspects of their doctoral research as they will not graduate if the papers are not published or in press. This approach ensures that the work of the student enters the public domain before the thesis is examined, providing the examiner with some assurance of prior peer review. The thesis must constitute a full study of the magnitude expected of a PhD with the papers providing a sound thread or storyline. Furthermore, the college maximizes the students' work as PUs are awarded for the papers as well as for graduating. However, this approach may negatively affect throughput and frustrate students as

they cannot graduate unless all the papers are published or in press, in addition to the synthesis chapter demonstrating the story line of the thesis.

The option of a thesis by manuscripts ensures that students make efforts to start publishing. The risk of not passing because of failure to publish all papers (as in the thesis by publication) does not exist under this option. However, the PUs emanating from publications from the doctoral work are not guaranteed as the submitted papers may eventually be rejected. Thus there is a possibility of the doctoral work remaining on the university library shelves as is the case for the standard thesis format. The standard thesis does have the advantage that more details of the doctoral work are usually included.

In view of the above, the best option for the college is that of a thesis by publication. However, in the interim, the attractive option is that of thesis by manuscripts, as it provides the possibility of publication without putting the student at risk of delayed graduation when some of the manuscripts are not published/accepted, which also disadvantages the college in terms of PU earnings. The standard thesis option should ultimately be phased out for the stated reasons and students are not encouraged to present their theses in that format. Consequently this document does not describe the standard thesis.

2.2 MSc dissertation

The rules on presentation of MSc dissertations are presented in CR13 (course work), CHS 14 (course work) and MR9 (research) in the CHS Handbook. CR13 c and MR9 c direct that a dissertation "may comprise one or more papers of which the student is the prime author, published or in press in peer-reviewed journals approved by the relevant college academic affairs board or in manuscripts written in a paper format, accompanied by introductory and concluding integrative material." Such a dissertation should include a detailed description of the student's own distinct contribution to the papers. Both CHS14 and CR13 specify that reviews and other types of papers in addition to original research paper/s may be included, provided they are on the same topic.

3 ***Length of thesis and dissertation by word count***

Table 1 provides a guide of the length of a thesis or dissertation by word count excluding preliminary pages and annexes.

Table 1: Thesis length by word count

Sections				
	Minimum	Maximum	Minimum	Maximum
Introduction	2700	2700	2000	2000
Chapters	10000	25000	6000	11000
synthesis	2000	2000	1700	1700
bridging	300	300	300	300
Total	15000	30000	10000	15000

4. ***Intention to submit***

A written intention to submit a thesis or dissertation should be submitted to the appropriate postgraduate office with endorsement of the supervisor at least three months before the actual date of submission which should be before November if the student intends to graduate in the following year. The actual submission will under normal circumstances require approval of the supervisor.

5. Format for theses/dissertation

There is little variation in the actual format of the PhD thesis and Masters dissertation for the various types described above. The box below summarise the outline of a thesis/dissertation for the thesis by manuscripts and thesis by publications.

Box 1: Outline of thesis

Preliminary pages

i. Title page
ii. Preface and Declaration
iii. Dedication
iv. Acknowledgements
v. Table of contents
vi. List of figures, tables and acronyms (separately presented)
vii. Abstract

Main Text

1. Chapter 1: Introduction
   Introduction including literature review
   Research questions and/or objectives
   Brief overview of general methodology including study design
2. Chapter 2
   First manuscript/publication
3. Chapter 3
   Second manuscript/publication
4. Chapter n
   Final manuscript/publication
5. Chapter n+1: Synthesis
   Synthesis
   Conclusions
   Recommendations
6. References Appendices

NB. Between the manuscripts or publications there must be a 1 page (maximum) bridging text to demonstrate the link between them

6. Details for thesis/dissertation subheadings

This section summarizes what is expected under each subheading shown in Boxes 1 and indicates where there might be variations between a Masters Dissertation and PhD Thesis.

6.1 Title Page

The officially approved title that is concise (Fewest words that adequately describe the contents of the thesis/dissertation – usually 15 or fewer words) is presented at the top. This should be followed by the candidate's name in a new line. At the bottom the thesis statement should be presented. The thesis statement may be stated as "*Submitted in fulfillment of the requirements for the degree of ____ in the School of _____, University of KwaZulu-Natal"* for a PhD/Masters by Research thesis. In the case of a Masters Dissertation it should be stated as "Submitted as the dissertation component in partial fulfilment (% stated) for the degree of _____ in the School of _____, University of KwaZulu-Natal". For both Masters and PhD the date of submission must be stated.

6.2 Preface (Optional)

The preface merely states the reason (motivating factors) why the study was conducted without getting into details of what was investigated.

6.3 Declaration

This must be structured as follows:

I, Dr/Mr _____, declare as follows:

1. That the work described in this thesis has not been submitted to UKZN or other tertiary institution for purposes of obtaining an academic qualification, whether by myself or any other party.

   Where a colleague has indeed prepared a thesis based on related work essentially derived from the same project, this must be stated here, accompanied by the name, the degree for which submitted, the University, the year submitted (or in preparation) and a concise description of the work covered by that thesis such that the examiner can be assured that a single body of work is not being used to justify more than one degree.

2. That my contribution to the project was as follows:
   This is followed by a concise description of the candidate's personal involvement in and contribution to the project, in sufficient detail that the examiner is in no doubt as to the extent of their contribution.

3. That the contributions of others to the project were as follows:
   This is followed by a list of all others who contributed intellectually to the project, each accompanied by a concise description of their contribution. This does not include people who ordinarily would be "acknowledged" as opposed to considered for authorship.

4. Signed _____ Date_____

6.4 Dedication

This is an optional section. Should it be included it must be very brief merely indicating to whom the work is dedicated. Avoid anything too flowery

6.5 Acknowledgements

This section acknowledges all individuals, groups of people or institutions that the candidate feels indebted to for the support they rendered. The funding source for the work should also be acknowledged.

6.6 Table of contents

Table of contents must be inserted after the preliminary sections and must capture all major sections of the thesis at the various levels (primary, secondary, tertiary subheadings). It should be electronically generated and should be able to take the reader to specific headings in the thesis.

6.7 Lists of figures, tables and acronyms

These lists must be presented separately. All titles of figures presented in the thesis/dissertation must be listed indicating on what page they appear. Similarly for tables the titles must be presented indicating on what page they appear. In the case of acronyms, the acronym is stated and all the words describing the acronym are presented. Only key acronyms should be stated. In some cases they may not be listed as long as full text is presented whenever the acronym is used for the first time.

6.8 Abstract

The abstract should summarize the thesis mainly stating the purpose of the study, highlights of chapters and the new knowledge contributed by the thesis. The abstract must be approved by the supervisor of the thesis and should not be more than 350 words in length.

6.9 Introduction

The introductory chapter for both types of thesis is similar. The section should include literature review and have the following information. Headings are used as appropriate and need not correspond exactly to the following.

i. Background and the context of the study
ii. Description of the core research problem and its significance
iii. A comprehensive, critical, coherent overview of the relevant literature leading to clearly defined knowledge gaps
iv. A coherent problem statement highlighting the nature and magnitude of the problem, the discrepancy, knowledge gaps therein and possible factors influencing the problem.
v. Clear and SMART research questions, objectives and hypothesis and/or theoretical framework
vi. A conceptual framework (optional)
vii. Description of the study area and general methodology *(in a standard thesis this should be a stand-alone section)*
viii. Layout of the thesis (thesis structure) indicating what chapters are presented in the thesis and how they address the objectives.

6.10 Literature review

This section is subsumed in the introduction within the stipulated word count for a thesis or dissertation.

6.11 Methodology

A standalone section is not needed as the methods are adequately described in each manuscript/publication.

6.12 Data chapters/manuscripts/publications

The full published paper or manuscript submitted for publication should be presented as published or submitted to the journal. The actual published paper should be scanned and inserted

in the chapter. There should be a separator page between chapters that has text linking the previous chapter to the next and providing details of the next manuscript/publication indicating publication status.

6.13 General discussion/Synthesis chapter

This is a general discussion that demonstrates the logical thread that runs across the various manuscripts/publications (synthesis). There should be no doubt that the manuscripts/publications complement each other and address the original objectives stated in the general introduction of the thesis. The general discussion/synthesis chapter should end with a conclusion and recommendations where necessary.

6.14 References

Only references cited in the introduction and synthesis chapters should be listed as all other references should be within the manuscripts presented under data chapters.

6.15 Annexes

All information (questionnaires, diagrams, ethics certificates, etc) considered important but not essential for inclusion in the actual thesis is put in this section as reference material. In addition papers that emanated from the work but not directly contributing to the thesis may be included.

7. Thesis formatting

For standardisation of thesis the following formatting specifications should be followed.

7.1 Font

Times New Roman 11pt should be used throughout the thesis. However, major headings may be made bigger (12pt) but using the same font type

7.2 Paper size and margins

A4 (297 x 210 mm) should be used and in the final thesis both sides of the paper should be used. However, the loose bound copy submitted for examination should be printed on only one side. The recommended margins are 30mm for all the left, right, top and bottom margins.

7.3 Line spacing

The copy submitted for examination should have 1.5 line spacing but the final copy should have single line spacing. Paragraphs should be separated by a blank line. Published or submitted manuscripts should remain in their original format in all aspects as they are inserted in their published format in appropriate places.

7.4 Headings

A consistent numbering system and captions should be maintained with first level being in CAPS and centred, second level being **normal bold** font and third level being ***italics bold***. If there is need for 4th level it should be *normal italics*.

7.7 Pagination

Page numbers should be centred at the bottom of the page. All preliminary pages should be numbered in lower case Roman numerals and subsequent pages should be numbered as indicated in the Box The title page should not be numbered.

The body of the thesis (chapter 1 onwards) should be numbered consecutively with Arabic numerals. The numbers should continue consecutively from the introduction through the through the publications or submitted manuscripts and subsequent sections. The published papers will therefore bear two numbers: a set specific to the manuscript (it is recommended to place these in the upper right hand corner) or published paper, as well as the consecutive numbers belonging to the thesis as a whole. Care must be taken to distinguish these in terms of position and font.

7.8 Referencing

Supervisors have the freedom to decide the type of citation of references but there must be consistency. This is mainly applicable to the standard type of thesis. In the case of thesis by manuscripts or publications, individual papers will maintain the reference system of the journal but the supervisor can decide on the type of referencing for the introductory and synthesis chapters.

8. Final thesis submission

The thesis should be submitted for examination in a loose bound form accompanied by a PDF copy. After the examination process the final version PDF copy of the thesis must be submitted to PG office for onward submission to the library. It is not a requirement to submit a copy fully bound in leather cloth or similar material.

3.8 Appendix C: Journal Submission

3.8.1 Proof of submission to the Journal of Anatomy

Gmail Sherelle Moodley <sherelle.moodley@gmail.com>

Manuscript JANAT-2022-0344

1 message

Edward Fenton <onbehalfof@manuscriptcentral.com> Wed, Sep 14, 2022 at 11:47 AM
Reply-To: janat@dpag.ox.ac.uk
To: sherelle.moodley@gmail.com
Cc: janat@dpag.ox.ac.uk

14-Sep-2022

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Re The relationship between the auriculotemporal nerve and middle meningeal artery in a South African population (Moodley, Sherelle; Ishwarkumar, Sundika; Pillay, Pamela)

Your manuscript has been successfully uploaded for submission to Journal of Anatomy. The manuscript has been assigned the manuscript number JANAT-2022-0344.

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I will try to handle your manuscript as rapidly as possible and I will be in touch again shortly.

Thank you for submitting your manuscript to Journal of Anatomy.

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This letter has been generated electronically

3.8.2 *Journal of Anatomy's author guidelines*

Journal of Anatomy

Articles submitted to Journal of Anatomy are done so on the following conditions: that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere including electronically in the same form, in English or in any other language, without the written consent of the copyright-holder. There are no page charges, and charges are not made for colour, if, in the Editors' opinion it is essential. In all other cases costs must be borne by the author. The Editors-in-Chief of Journal of Anatomy endorse the ARRIVE guidelines for reporting experiments (**https://www.nc3rs.org.uk/arrive-guidelines**), and expect authors to refer to these guidelines before submission of a manuscript. More information about reporting guidelines can be found at: **https://authorservices.wiley.com/ethics-guidelines/research-ethics-in-journal-article.html.**

NIH-funded authors and *Journal of Anatomy*

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Comparative functional morphology
Developmental biology
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Evolutionary morphology
Integrative vertebrate paleontology
Methodological innovations in anatomical research
Musculoskeletal system
Neuroanatomy and neurodegeneration
Significant advances in anatomy education

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The acceptance criteria for all papers are the quality and originality of the research and its significance to journal readership. Please note, manuscripts are **single-blind** peer reviewed: the identity of the reviewer is anonymous (unless the reviewer does not wish to be), but the author name and affiliation is on the paper.

PRESENTATION

Text

Authors should refer to recently published manuscripts for an overall guide to Journal style (available at **http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1469-7580**).

Text should be divided into the following sections and appear in the order:

(1) title page (with short running page heading, title, authors names and affiliations);
(2) abstract (no longer than 500 words, in a single paragraph, not divided into sections with headings);
(3) keywords;
(4) main body: introduction, methods, results, discussion (this may be combined with the results section) and conclusions if desired;
(5) acknowledgements;
(6) author contributions (see below);
(7) references;
(8) supplementary material (if any);
(9) tables; and
(10) figure legends.

Please avoid the use of footnotes, and number the pages using the page numbering feature of the word processing software.

Authorities for the Latin binomial of every organism are not used in the title or summary, and only on the first mention in the main body of the text. Gene names and loci should be in italic text and protein names should use in roman text.

Virus nomenclature (and acronyms) should follow the guidelines of the International Committee on the Taxonomy of Viruses (ICTV). The current report is: van Regenmortel MHV, Fauquet CM, Bishop DHL (Eds) (2001) Virus Taxonomy: Seventh Report of the International Committee on Taxonomy Viruses. San Diego: Academic Press. Authors are also advised to check the ITCV website for the latest information.

Chemical nomenclature should follow the International Union of Pure and Applied Chemistry (IUPAC) definitive rules for nomenclature.

Industrial products should be referred to by their common names (ISO Publications 1831, 2474, etc.). In the absence of a common name, use the full name or a defined abbreviation, in preference to a trade name. At first mention, trade names should be capitalised.

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References in the list should follow the Harvard system. Over 6 authors will be abbreviated to 3 authors et al. Refer to a recent copy of the journal for examples.

We recommend the use of a tool such as EndNote or Reference Manager for reference management and formatting.

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Numerical results should be presented either as tables or figures, but not both. The Journal welcomes colour figures and plates, when information would be lost if reproduced in black and white.

Tables: Tables should be typed on separate pages, as an integral part the text file. They should have a brief descriptive title and be self-explanatory. Units should appear in parentheses in the column headings, not in the body of the table. Repeated words or numerals on successive lines should be written in full. Footnotes should be minimal. When the precision of data is expressed as standard error (se) or standard errors of differences (sed) the degrees of freedom (df) should be given.

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3.9 Appendix D: TRREE Certificates

TRREE

Zertifikat
Certificat
Certificado
Certificate

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Professeur Dominique Sprumont
Coordinateur TRREE Coordinator

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3.10 Appendix E: Turnitin Report

Thesis Masters

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