

**A MORPHOLOGICAL STUDY OF THE
LINGULA IN SOUTH AFRICANS IN
RELATION TO SAGITTAL SPLIT
OSTEOTOMY**

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**A research report submitted to the Faculty of Health Sciences,
University of the Witwatersrand, Johannesburg, in partial
fulfilment of the requirements for the degree of**

**Master of Dentistry in the branch of Maxillofacial and Oral
Surgery**

Johannesburg, 2013

DECLARATION

I, Clinton Munsamy, declare that this research report is my own work. It is being submitted for the degree of Master of Dentistry in the branch of Maxillofacial and Oral Surgery to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

.....

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.....day of, 2013

ABSTRACT

The sagittal split ramus osteotomy is a common procedure used to correct jaw deformities. The lingula is an important anatomical landmark that is used as a reference to position the horizontal osteotomy cut on the medial aspect of the mandible. Knowledge of its position in relation to surrounding anatomical structures is essential in order to prevent complications related to the procedure.

The aim of this study was to provide medical and dental practitioners with useful data regarding the position of the lingula in relation to surrounding anatomical landmarks. Such data may be of clinical relevance when performing surgery on the mandibular ramus and when providing anaesthesia for routine dental procedures.

The study involved anthropometric measurements on adult dry mandibles obtained from the 'Dart Collection' at the School of Anatomical Sciences, University of the Witwatersrand, Johannesburg. A total number of 113 adult human dry mandibles were studied. From these specimens, 201 sides were examined.

The most common shape of lingula noted within the study was that of the truncated type which was found in 38.8% of cases, followed by the triangular, nodular and assimilated types which comprised 30.8%, 21.4% and 8.9% respectively. The average distance of the tip of the lingula from the anterior border, posterior border and sigmoid notch the ramus of the mandible was approximately 20.15mm, 16.77mm and 16.3mm respectively. The average distance of the tip of the lingula from the mandibular second molar tooth was found to be 33.3mm. The lingula was above the level of the occlusal plane in 63.7% of cases, by an average distance of 6.5mm. The width and height of the mandibular foramen exhibited great variation. Anatomical differences in Caucasian and Black mandibles were noted, with the

rami of Caucasian mandibles generally being smaller in dimension compared to black mandibles.

The anatomic data provided by this study may assist surgeons to locate and identify the lingula without difficulty, and avoid intraoperative complications. The data presented has a direct relevance to clinical practice and teaching.

DEDICATION

To my dearest wife Thanusha and our beautiful son Matthew,

My parents Stanley and Vasantha

For your love, encouragement, patience and prayers...

*The Lord giveth wisdom:
Out of his mouth cometh
knowledge and understanding.
He layeth up sound wisdom for the
righteous:
He is a buckler to them that walk rightly.
Proverbs 2:6-7*

ACKNOWLEDGEMENTS

I wish to express my gratitude to Dr. Ephraim Rikhotso, my supervisor, for his time and guidance in helping me to complete this research report

Special thanks to Mr Brendan Billings, curator of the 'Dart Collection' at the School of Anatomical Sciences, University of the Witwatersrand, Johannesburg, for his assistance with the specimens.

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LIST OF ABBREVIATIONS

- ❖ **SSRO – sagittal split ramus osteotomy**
- ❖ **IAN – inferior alveolar nerve**
- ❖ **SNAPs – sensory nerve action potentials**

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1.0 Introduction

The sagittal split ramus osteotomy (SSRO) was first demonstrated by Obwegeser and Trauner in 1955.¹ It provided oral and maxillofacial surgeons with a versatile method for correcting common dentofacial abnormalities such as prognathism and retrognathism, which are caused by overgrowth (hyperplasia) or undergrowth (hypoplasia) of the mandible respectively.² Many modifications of the original technique were made by the likes of Dalpont³, Hunsuck⁴, Bell,⁵ and Epker.⁶ The SSRO allows for an intra-oral approach to mandibular ramus surgery, rapid healing, and easy rigid internal fixation that promotes early jaw function. Several anatomic landmarks have been proposed to guide surgeons in locating and avoiding the IAN. These include various radiographic techniques as well as anthropometric measurements using dry human skulls, but these are few and have been shown to be population specific.^{7,8}

The SSRO consists of making a horizontal osteotomy on the medial surface of the mandibular ramus, a sagittal osteotomy along the anterior border of the mandibular ramus and internal oblique line and a vertical body osteotomy.^{6,9} An important clinical landmark for performing the horizontal ramus osteotomy is the lingula. This osteotomy line should be made just above the lingula and extend posteriorly to it in order to make a safe split, which minimizes the potential for inferior alveolar nerve injury.^{4,5,6,9}

The lingula is defined as a tongue shaped bony projection on the medial surface of the ramus close to posterior margin of the mandibular foramen. It was first described by Johannes Baptist Spix in 1815, and following his description it was referred to as ‘Spix’s ossicle or spine.’¹⁰ It lies in close proximity to the mandibular foramen. Failure to accurately identify the lingula intra-operatively when performing a sagittal split ramus osteotomy can result in a number of known complications, such as an unfavourable split, transection of the inferior

alveolar vessels which results in haemorrhage and damage to the vessels and nerves within the vicinity of the osteotomy.^{11,12,13,14}

Both the shape and the position of the lingula on the medial aspect of the ramus of the mandible are highly variable.^{15,16,17} Whilst certain shapes, such as the classically described triangular shape, make for easier identification of the structure intra-operatively, others such as the nodular and assimilated shapes are much more difficult to recognise. Therefore an accurate knowledge of the anatomy of the medial aspect of the ramus of the mandible is imperative in order to prevent complications associated with sagittal split ramus osteotomies.

There exists wide racial and regional variation in the metric characteristics of the mandible as well as the position of the lingula due to genetic and environmental factors, as well as functional activity which is thought to play a secondary role in determining the anatomy of the mandible during the early stages of development.¹⁸ Thus the position of the lingula and anatomy of the medial aspect of the ramus of the mandible has the propensity to demonstrate variations amongst different populations. Various studies have reported both similarities and disparities with regard to the position of the lingula and anatomy of the medial aspect of the ramus of the mandible.^{9,15,16,17} This makes surgery involving the ramus of the mandible dependant on population specific parameters.

In South Africa, no study has been conducted on dry mandibles to evaluate the position of the lingula in relation to surrounding anatomical structures and the lower molar teeth. This study was conducted to provide an insight on the potential population differences by comparing the results of the study with data previously published in the literature and to provide clinicians with reliable clinical landmarks when performing surgery on the mandibular ramus as well as to provide useful insights to the position of the IAN when delivering local anaesthesia for various dental procedures.

2.0 Literature Review

2.1 The Shape of the Lingula

Nicholson¹⁹ and DuBrul²⁰ reported the presence of various shapes but did not describe them. Textbook illustrations often fail to describe the existence of forms other than classic triangular (or tongue-shaped) form, i.e. the truncated type depicted by Hollinshead,²¹ the nodular type shown by Berkovitz et al,²² Sampson²³ and Williams et al²⁴ and the assimilated type shown by Morgan et al.²⁵ The shape of the lingula is important, as surgeons commonly use this landmark when performing mandibular osteotomies.

The shape of the lingula corresponds to anthropological markers for different populations,²⁶ and can be used to assess different populations and races along with non-metric variants of the skull.²⁷ Results from a study conducted on 72 dry Thai mandibles (144 sides) found that the truncated shape (47%) was most common followed by nodular (23%), triangular (17%), and assimilated (13%) shapes.²⁶ In a similar study conducted in India, 68% of mandibles demonstrated triangular shaped lingulas, 15.8% truncated, 10.9% nodular and 4.8% assimilated.¹⁷ Hoosein et al also conducted a study on 208 Bangladeshi human mandibles and found that 70.2% of the lingulas were triangular in shape, 20.2% truncated and 9.6% assimilated.²⁸ Thus, from these studies it becomes apparent that considerable variation may exist with regard to the shape of the lingula amongst different populations.

Whilst it is often easier to identify the classically described triangular shape when performing surgery on the medial aspect of the ramus of the mandible, this shape is not always the most common. It is, however, often challenging to identify the lingula if it is assimilated or nodular in shape, and thus knowledge of the anatomical location of the structure is invaluable.

2.2 Location of the lingula

The precise location of the lingula is clinically significant as it serves as an important anatomical landmark when performing surgery involving the medial aspect of the mandibular ramus. Identification of the lingula intra-operatively may assist in avoiding vital structures, such as the inferior alveolar nerve (IAN) and vessels, present on the medial aspect of the ramus of the mandible.

An analysis of reports from various countries around the world has shown that the location of the lingula varies among different ethnic and racial groups.^{15,17} In a recent study conducted in Thailand, investigators found that the lingula was located approximately 20.6mm from the anterior border of the mandibular ramus, 18.1mm from the posterior border and 16mm from the mandibular notch.¹⁵ The study also found that in the majority of cases, the lingula was located above the level of the occlusal plane. From their results, the authors were able to provide medical and dental practitioners with guidelines for efficient anaesthesia for dental treatment as well as guidelines for mandibular osteotomies in Thai patients. In comparison to similar studies conducted in other parts of the world, the authors found that the shape and position of the lingula in relation to surrounding structures in Thais varied from other races.¹⁵

Results from a similar study carried out on 242 dry Korean mandibles, of unknown sex and age; found that the lingula was located approximately 17.4mm from the anterior border of the mandibular ramus and 15.4mm from the mandibular notch.⁸ The authors were also able to measure the distance from the distal side of the mandibular second molar to the tip of the lingula, which was found to be approximately 28.7mm. According to the authors, this measurement should prove helpful to clinicians by providing them with guidelines as to where they should expect to find the lingula, and protect the inferior alveolar vessels and nerve when performing surgery involving the mandibular ramus.⁸ The lingula, like in most

other studies, was found to be above the occlusal plane with an average vertical distance of approximately 5.9mm in adult mandibles.⁸

A number of studies have focused on determining the position of the mandibular foramen and have determined a relationship of the lingula to the structure.^{18,19} In one such study conducted on dry adult Zimbabwean mandibles by Mbajjorgu,¹⁸ the height of the lingula was measured with respect to the position of the mandibular foramen. This study concluded that the mandibular foramen was highly individualistic, being located 2.56mm (on the right side) and 2.08mm (on the left side) behind the midpoint of the ramus and approximately 3mm above the midpoint of the ramus on both sides. He also noted that the height of the lingula (distance from the mandibular foramen to the highest point on the lingula) showed great variation, but on average was 8.40mm (on the right side) and 8.36mm (on the left side).¹⁸ This study refutes the assumption that the lingula and the mandibular foramen were on the same level above the occlusal plane.²⁹ The author was lead to conclude from his study that when performing a mandibular block of the inferior alveolar nerve, the needle be directed 1.5mm to 2.5mm above the occlusal plane as this will ensure that the needle be directed into the pterygomandibular space for successful IAN anaesthesia in 76.5% of black Zimbabweans.¹⁸

Nicholason,¹⁹ in his determination of the mandibular foramen based on anthropometric measurements of dry human mandibles of East Indian ethnic origin, found that the foramen was predominantly located in the anteroposterior midpoint of the ramus halfway between the mandibular notch and the lower surface of the mandible and two thirds of a line joining the coronoid process and the angle of the mandible. The study also found that in 75% of cases, the mandibular foramen was located below the level of the occlusal plane, which is in contrast to other studies.¹⁸

Monazzi et al,⁷ in a study conducted in Brazil on 44 human cadaver dry mandibles, found that the lingula was approximately 16.5mm from the anterior border of the ramus, 14.6mm from the posterior border, 16.3mm from the sigmoid notch and approximately 27mm to the lower border of the mandible. The tip of the lingula was located approximately 5.82mm from the mandibular foramen.⁷

In a recent prospective study conducted in Johannesburg, South Africa, investigators evaluated the effect that impacted third molars have on sagittal split ramus osteotomy.³⁰ The authors also attempted to define the position of the lingula based on measurements made from a standard panoramic radiograph. They found that the distance of the lingula from the anterior border of the ramus ranged from 16mm to 18mm.³⁰ Another South African study conducted in the mid-seventies attempted to identify the position of the lingula in relation to structures present on the external surface of the ramus, namely the masseteric apical bump, or more commonly known as the antilingula.³¹ This structure, however, is not always present and cannot be readily identified clinically.³¹ No study, to date, has been conducted in South Africa with the aim to identify the position of the lingula in relation to surrounding anatomical landmarks based on anthropometric measurements of dry human mandibles.

2.3 The Significance of the lingula in SSRO

Due to its relationship to the alveolar nerve, the lingula has been a main anatomic landmark to guide surgeons.³² Obwegeser and Trauner,¹ who first introduced the classical SSRO for correction of various facial discrepancies, suggested that the medial horizontal osteotomy be made high 'just below the mandibular notch.' However, recent studies indicate that the osteotomy be placed just above the lingula.^{9,32,33} This is mainly due to the fact that placement of the horizontal osteotomy too far above the lingula (which is used as a reference point

intraoperatively) places the cut in predominantly cortical bone,^{9,33} increasing the risk of an unfavourable fracture.^{9,32,33,34}

In 1968 Hunsuck⁴ introduced the short medial osteotomy which allowed for less medial soft tissue reflection and better control of the bone cut because the proximal end is better visualised. Dal Pont,³ Hunsuck,⁴ and Epker⁶ also noted that the medial horizontal osteotomy should only extend as far posteriorly as the lingual fossa; the mean length being 18mm.^{3,4,6} Wolford et al³⁴ modified the initial surgical technique described by Obwegeser and Trauner.¹ The authors suggested that the medial osteotomy be directed perpendicular to the ascending ramus at the level of the superior aspect of the lingula and carried to the depth of the medial surface of the buccal cortex. They also noted that by performing the medial horizontal osteotomy through the superior aspect of the lingula facilitates a less problematic split. The reason for this was that the more superior the level of the ramus, the less interposed medullary bone there is, and the greater the incidence of fusion between the buccal and lingual plates of the ramus of the mandible. Also by keeping the medial osteotomy cut perpendicular to the ascending ramus (as opposed to parallel to the occlusal plane) keeps the posterior aspect of the cut lower facilitating easier splitting of the segments.

Complications of sagittal split ramus osteotomies include unwanted fracture of either the distal or proximal segments (bad split), bleeding, inadequate fixation and relapse.^{12,13,14} These complications may occur as a result of variations in the anatomy of the medial aspect of the mandible, inability to identify vital structures such as the lingula and mandibular foramen when performing the surgery, inexperience of the surgeon or incorrect technique employed.

2.3.1 Unfavourable fractures ('bad split')

Incorrect placement of the horizontal osteotomy may lead to an unfavourable or bad split.^{9,14,35} In order to ensure a successful split of the mandible, attention has to be paid not

only to the antero-posterior position of the lingula, but also to its supero-inferior position.^{35,36} Placement of the osteotomy cut too far superiorly above the mandibular foramen positions the cut in the thinner part of the ramus, increasing the risk of a bad split, as the fracture line may be within purely cortical bi-laminar bone, whilst not extending the cut beyond the mandibular foramen may result in the posterior aspect of the sagittal split between the proximal and distal segments being located anterior to the foramen.^{9,32} Thus the inferior alveolar bundle may be contained in the proximal segment, and freeing of the bundle may result in nerve injury or bleeding.³⁵ Numerous studies have found that placement of the medial osteotomy at or above the point of fusion may result in an unfavourable fracture.^{9,33} Smith et al.⁹ found that in only 2% of cases, there was fusion of the buccal and lingual cortices of the ramus of the mandible at or below the lingula in the anterior part of the ramus, and 6.1% in the posterior part of the ramus. They also found that at a distance of 7.5mm to 13.3mm above the lingula, buccal and lingual cortex fusion occurs at a rate of 20% in the anterior ramus and 39% in the posterior ramus. This study led the author to conclude that the medial horizontal cut be made at or just above the tip of the lingula because a higher cut may be associated with increased difficulty in splitting the mandible which may result in an unfavourable fracture.⁹ Thus, an intimate knowledge of the position of the lingula as well as the mandibular foramen is essential when performing a SSRO.

Tom et al.³³ conducted a study on 48 cadaver hemimandibles to identify the point of fusion between the buccal and lingual cortical plates with the aim of better directing the horizontal medial osteotomy in sagittal split ramus osteotomies. This was done by performing various vertical sections through the ramus of the mandible. The authors concluded that if the osteotomy is initiated approximately 5mm or more above the lingula, then the probability of the cut ending in a point of fusion is increased, which thus increases the probability of a bad

split. He therefore advised that the medial osteotomy be placed near the tip of the lingula as this area has sufficient width of bone with an adequate cancellous layer.³³

Placement of the cut too far superiorly, in order to avoid the inferior alveolar vessels and nerve, increases the risk of a bad split, whilst placement of the osteotomy too far inferiorly on the ramus increases the risk of damage to these structures.

2.3.2 Inferior alveolar nerve injury

One of the major complications of SSRO includes impairment of the inferior alveolar nerve (IAN), damage which may result in permanent numbness or altered sensation of the lower lip and chin area. This can affect a patient's quality of life due to adverse effects on speech, eating and drinking which may lead to psychological and social interaction issues.³⁷ The incidence of inferior alveolar nerve damage following SSRO is reported to range from 2% to 15%.⁷

Some studies have attempted to evaluate the mechanism of IAN injury based on indirect evidence from post-operative sensory tests.^{37,38} There is little data to indicate the actual stage of SSRO that carries the greatest risk for IAN injury. This prompted Teerijoki et.al.³⁹ to conduct a study in which sensory nerve action potentials (SNAPs) of the IAN were continuously monitored in 20 patients undergoing bilateral sagittal ramus osteotomy. Changes in latency, amplitude and sensory nerve conduction velocity at baseline and at different stages of the operation were analysed. The results of the study indicated that the most obvious changes in all parameters and highest risk to damage of the IAN occurred during preparation of the medial side of the ramus. Risk of injury to the IAN was directly proportional to the time taken to prepare the medial side of the ramus, with SNAPs disappearing usually after 10 minutes. On clinical evaluation, the authors also reported that in 7 cases the IAN was lacerated.³⁹ From this study it becomes apparent that the greater

knowledge of the anatomy of the ramus of the mandible one has, the shorter the preparation time of the medial horizontal osteotomy with less risk of IAN injury.

2.3.3 Haemorrhage

Haemorrhage is one of the complications that may occur when performing a sagittal split ramus osteotomy. The incidence is thought to be between 0.39% - 38%, but there are no uniform criteria defining bleeding complications within the literature.³⁸ Haemorrhage following orthognathic surgery is usually the result of insufficient surgical haemostasis after mechanical disruption of blood vessels, rather than acquired or congenital coagulopathy.⁴⁰ Blood vessels close to the osteotomy line include the internal carotid artery, retromandibular vein, maxillary artery, facial artery and vein and the inferior alveolar artery and vein. Behrman¹⁴ reported that 38% of surgeons reported haemorrhage as a complication of sagittal split ramus osteotomy, with 50% of those indicating that it was a severe problem. According to the report of the study conducted by Behrman, the principal source of bleeding was the maxillary artery, followed by the facial artery, inferior alveolar artery and retromandibular vein.¹⁴

Recent reports have not found haemorrhage to be a major problem when performing sagittal split ramus osteotomies.^{38,40} According to a study conducted by Tetzrow et.al,³⁸ in which 1274 consecutive patients were reviewed for perioperative complications following sagittal split ramus osteotomy, 15 patients (1.2%) were reported as having acute haemorrhage as a complication. The authors reported that the retromandibular vein was most often severed, followed by the facial artery. In 9 cases the vessel was not identified. The authors also stated that when the inferior alveolar vessel was severed, achieving haemostasis was usually not a problem. One patient, however, did develop a massive swelling and haematoma and required a tracheostomy.³⁸

In 8 of the 21 cases of haemorrhage following SSRO or intra-oral vertical ramus osteotomy reported by Lanigan et al,⁴⁰ the maxillary artery was severed intra-operatively, most often resulting from the medial horizontal osteotomy cut. Brisk bleeding was encountered, but no deaths reported as a result of the complication. However, in two cases the patients were taken back to the operating theatre to control the bleeding. Four cases required ligation of the external carotid artery, which often results in increased operating time and more extensive neck dissection. In one case the inferior alveolar artery and vein were severed during the malleting of the right sagittal split ramus osteotomy, which resulted in severe bleeding that was poorly controlled intra-operatively by the attendant surgeons. The patient was transferred to the ICU intubated, but recovered with no major post-operative haemorrhage, according to the authors.⁴⁰

Often bleeding encountered within the maxillofacial area is difficult to visualise, which makes control of the haemorrhage challenging. Such was the case of a 26 year old female patient undergoing bilateral sagittal split ramus osteotomy for correction of mandibular prognathism and facial asymmetry.⁴¹ The left internal maxillary artery was inadvertently severed. The patient developed disseminated intravascular coagulation (DIC) from the massive haemorrhage that ensued. The patient subsequently required embolization of the external carotid artery to control the bleeding. Bleeding from the internal maxillary artery is often difficult to control, due the difficulty in locating and ligating the artery intra-operatively, as well as the numerous anastomoses possessed by the maxillary artery.⁴²

2.4 The importance of the lingula for dental anaesthesia

Knowledge of the position of the lingula is not only pertinent to those performing surgery on the ramus of the mandible, but also to dentists who administer local anaesthetic for a

mandibular block, with the anaesthetic solution being deposited in the region of the lingula of the mandible. Incorrect technique or inadequate knowledge of the anatomy of the medial aspect of the ramus of the mandible may result in failure of the mandibular block, or more importantly damage to the inferior alveolar or lingual nerves. Local anaesthesia of the inferior alveolar nerve is achieved most commonly through the Halsted technique, whereby local anaesthetic is deposited in the pterygomandibular space where the IAN enters the mandibular foramen.⁴³ The lingula overlies the mandibular foramen, and knowledge of its position is imperative when performing a mandibular block. It has been shown that racial and regional differences in functional activity involving the mandible during early stages of development may affect the size and shape of the mandible and thus the position of the mandibular foramen.¹⁸ Failure rates as high as 29% for IAN anaesthesia have been reported,⁴⁴ which have been attributed to a number of factors including anatomic variability.⁴⁵ Mbajjorgu¹⁸ in his anthropometric study involving dry human mandibles conducted in Zimbabwe found that the lingula lies on average 5.6mm above the occlusal plane, and so suggested that the needle for local anaesthesia of the inferior alveolar nerve be directed 1.5mm to 2.5mm above the occlusal plane to ensure success of the mandibular block.

The etiology of nerve damage following dental injection is unknown.⁴⁶ In most cases it is thought to be related to chemical injury from a variety of anaesthetic agents, with articaine and prilocaine being cited more commonly.^{46,47} However, direct trauma from the needle cannot be excluded.⁴⁶ It is hypothesised that direct trauma may be related to the formation of an intraneural haematoma caused by the needle striking one of the smaller intraneural blood vessels.⁴⁷ Intraneural haematomas are known to be neurotoxic.⁴⁶ According to Hillerup,⁴⁷ a neuroma formed after direct injury to the nerve, may interfere with nerve conduction by intraneural pressure similar to a situation like compartment syndrome.

3.0 Aims and Objectives

3.1 Aim

The aim of this study is to provide medical and dental practitioners with useful data regarding the position of the lingula in relation to surrounding anatomical landmarks. Such data may be of clinical relevance when performing surgery on the mandibular ramus, and when providing anaesthesia for routine dental procedures.

3.2 Objectives

1. To identify the various shapes of the lingula and its occurrence
2. To determine the height and location of the lingula in relation to mandibular ramal landmarks
3. To determine the position of the lingula in relation to the mandibular second molar tooth
4. To determine gender and age differences with respect to the above criteria

4.0 Materials and Methods

4.1 Study setting

The study involved the use of the Raymond Arthur Dart Collection (commonly referred to as the “Dart Collection”) which is housed at the School of Anatomical Sciences, University of The Witwatersrand, Johannesburg, South Africa. It is the largest human skeletal collection within Southern Africa and comprises a total number of 2605 documented skeletons.

The collection originated in the early 1920’s as a result of the efforts of Raymond Dart, an Australian born anatomist, who took over Headship of the Anatomy Department of the recently established University of the Witwatersrand in January 1923. The cadaver derived skeletons that comprise the Raymond Dart collection have always been collected under the provision of South African Human Tissue Act (No. 65 of 1983, and by previous Acts eg. The Anatomy Act No. 20 of 1959). Prior to 1958, specimens within the collection were derived mainly from unclaimed bodies from Gauteng (previously Transvaal) Provincial Hospitals, but since then, a bequeathment programme has increasingly contributed to the collection, providing cadavers for teaching and research in medical sciences. The collection has become of significant importance for studies of forensic anthropology, population biology, human variation, dentistry, medicine, clinical anatomy, forensic pathology and palaeoanthropology.⁴⁸

The majority of information regarding the cadavers is derived from the death certificates of the specimens. The collection has a wide selection of ages that extends from 100 years to neonates, as well as a multitude of populations representing both sexes.

The study was conducted on the dry mandible specimens within the ‘Dart Collection’.

4.2 Inclusion Criteria

- Mandibles that were dentate, with dentition up to and including the mandibular second molar tooth
- mandibles in which the age, sex and race were known (identified according to historic records)

4.3 Exclusion Criteria

- mandibles that were edentulous, or that exhibited the presence of a bony defect or deformity or evident pathology

4.4 Data Collection

A digital sliding calliper was used to obtain linear measurements of the specimens (Mitutoyo^R, Japan, capable of measuring to the nearest 0.01mm). All measurements were carried out by the same investigator.

The mandibles were measured according to predetermined points. All measurements were determined to the tip of the lingula (defined as the highest point of the lingula). The following data was obtained:

- Shape of the lingula
- Position of the lingula in relation to ramal landmarks
 - o The distance of the lingula from the sigmoid notch was determined by measuring the distance from the deepest point of the sigmoid notch to the tip of the lingula (the highest point of the lingula)

- The distance of the lingula from anterior border of the ramus of the mandible was measured by drawing a line from the anterior border of the ramus to the tip of the lingula perpendicular to the line drawn from the deepest point of the sigmoid notch to the tip of the lingula
- The distance of the lingula from the posterior border of the ramus of the mandible was measured by drawing a line from the posterior border of the ramus of the mandible to the tip of the lingula perpendicular to the line drawn from the deepest point of the sigmoid notch to the tip of the lingula
- Position of the lingula in relation to the mandibular second molar
 - The distance was measured from the tip of the distobuccal cusp of the mandibular second molar tooth to the tip of the lingula (defined as the highest point of the lingula)
- Size of the mandibular foramen
 - The height of the mandibular foramen was measured as a vertical distance between the tip of the lingula and lower border of the mandibular foramen
 - The width of the mandibular foramen was measured as a distance from the anterior to the posterior borders of the foramen at the same level.
- Position of the lingula in relation to the occlusal plane
 - A flat instrument was used to determine the level of the occlusal plane
 - The lingula was defined as being:
 - At the level of the occlusal plane
 - Above the occlusal plane
 - Below the occlusal plane

Both the right and the left sides of the mandible were measured. In order to validate the data, an intraobserver reliability test was performed under the following conditions in order to establish repeatability of the measurements:

- the same measurement procedure was employed on a sample of specimens selected randomly
- measurements were performed by the same observer
- the same measuring instrument was used under the same conditions
- measurements were undertaken at the same location

In order to further ensure repeatability of the measurements, an inter-observer reliability test was performed under the same conditions stated above.

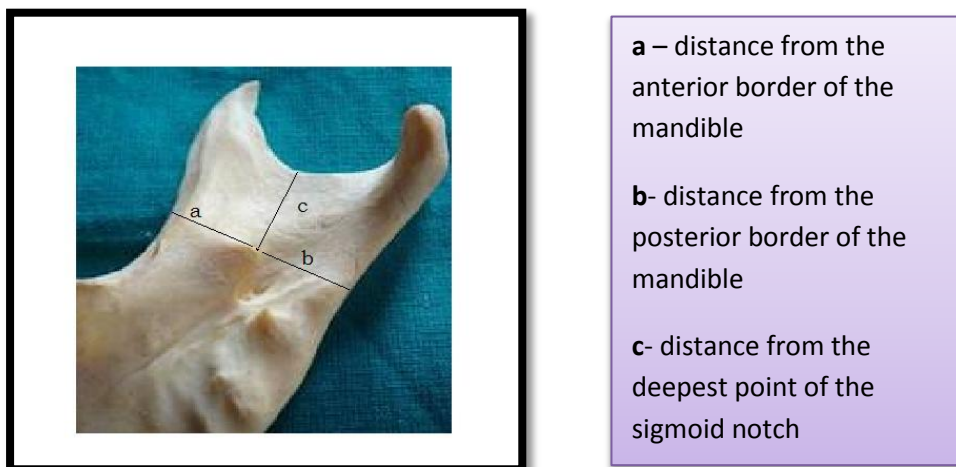
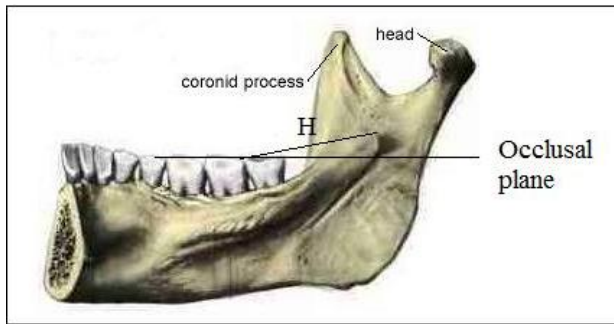


Fig 1. Position of the lingula in relation to ramal landmarks



H- Distance of the tip of the lingula from the tip of the disto-buccal cusp of the mandibular second molar

Fig 2: Position of the lingula in relation to the mandibular second molar tooth

4.5 Data Analysis

The data obtained was entered onto a data collection sheet. Refer to **Appendix 1** (attached herewith).

The data collected was analysed using descriptive statistics. The variables outlined on the data sheet (Appendix 1) were grouped into Left and Right groups. The following statistical methods were used to analyse the data:

- Percentage evaluation
- Correlation coefficients and coefficient of variation (used in the analysis of the interobserver and intraobserver error tests)
- Two sample t-test – to analyse differences between the left and right sides of the mandible such as the:
 - Distance of the lingula from the anterior border of the mandible
 - Distance of the lingula from the posterior border of the mandible
 - Distance of the lingula from the sigmoid notch
 - Distance of the lingula from the mandibular second molar tooth
 - Width and height of the mandibular foramen

- Standard Deviation (to determine how widely values are dispersed from the average value (mean))

Data was captured using Microsoft Excel 2010 (Microsoft Office Professional Plus 2010).

Data analysis, plotting of graphs and tables was carried out using Microsoft Excel 2010.

4.6 Ethical Considerations

Approval for the use of the human dry mandibles for research purposes has been obtained from the Department of Anatomy, University of the Witwatersrand from the Human Research Ethics Committee of South Africa. Ethics reference number- W-CJ-101109-1. See attached Ethics waiver (Appendix 2).

5.0 Results

In order to ensure accuracy and reproducibility of the measurements carried out on the specimens, both intraobserver and interobserver error tests were performed. A correlation coefficient of $> 93\%$ was obtained in all cases except when the error test was performed to determine the width of the mandibular foramen (See Fig. 3).

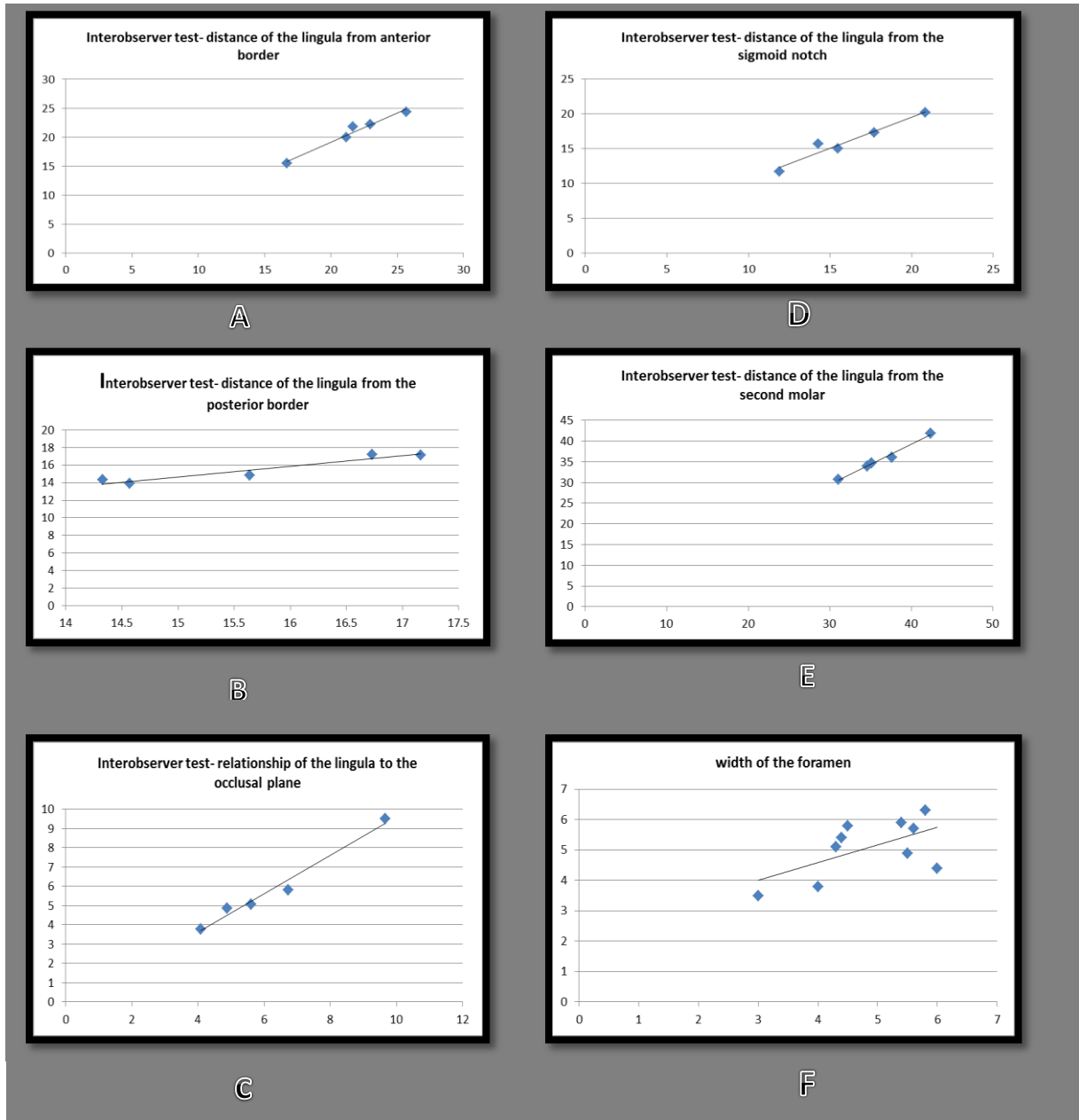


Fig 3: Interobserver testing of data (position of the lingula in relation to ramal landmarks): A- distance of the lingula from the anterior border of the mandible, B- distance of the lingula from the posterior border of the mandible, C- relationship of the lingula to the occlusal plane, D- distance of the lingula from the sigmoid notch, E- distance of the lingula from the second molar, F- width of the mandibular foramen

Due to the extensive variation of the mandibular foramen, especially in terms of its width, a correlation coefficient of 59% was observed. Fig. 1 illustrates a few of the error tests performed by the interobserver, as well as the error test for determination of the width of the mandibular foramen.

A total number of 113 adult human dry mandibles were selected from the Raymond Arthur Dart Collection at the Department of Anatomy, University of the Witwatersrand. From these specimens, 201 sides were examined. Both the right and the left sides were examined. In 25 cases, only one side was examined, either left or right, due to the omitted side not meeting the inclusion criteria.

From the 113 specimens included in the study, 77 (68%) were male and 36 (32%) were female mandibles. The age distribution of the specimens ranged from 20 to 50 years, with a mean of 40.2 years (See Fig 4).

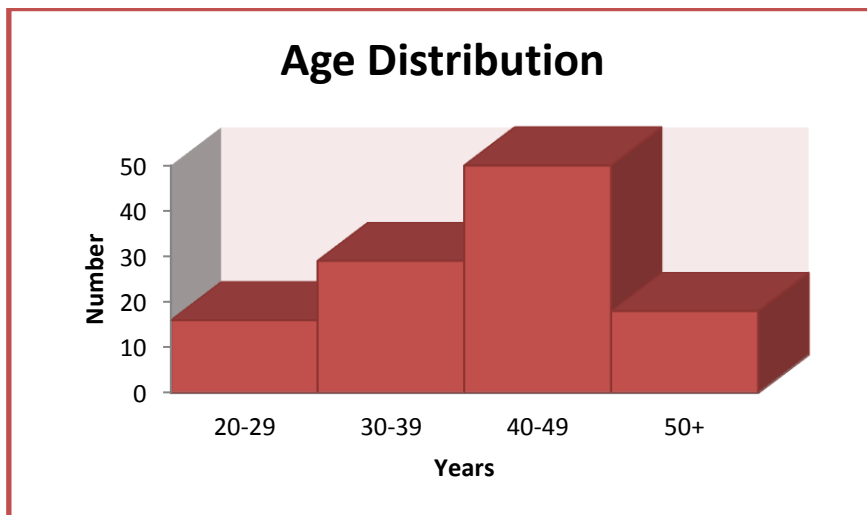


Fig 4: Age Distribution of Specimens

5.1 Shape of the lingula

The most common shape of lingula noted within the study was that of the truncated type which was found in 38.8% of cases, followed by the triangular, nodular and assimilated types which comprised 30.8%, 21.4% and 8.9% respectively (see Fig 5 and 6). In 26.4% of cases (93 mandibles), there was a difference between the right and left sides of the mandible with respect to lingula shape. The incidence of the truncated and assimilated types in the male and female mandibles was almost equal (see Fig 7). However, the triangular variant was more commonly noted in females, found in 35% of the cases examined, as compared to 26.4% in males. The nodular variant was noted more commonly in males (23.5%) than females (16.9%). The assimilated type was only marginally more common in females with an incidence of 9.2% as compared to the 8.8% noted in male mandibles.

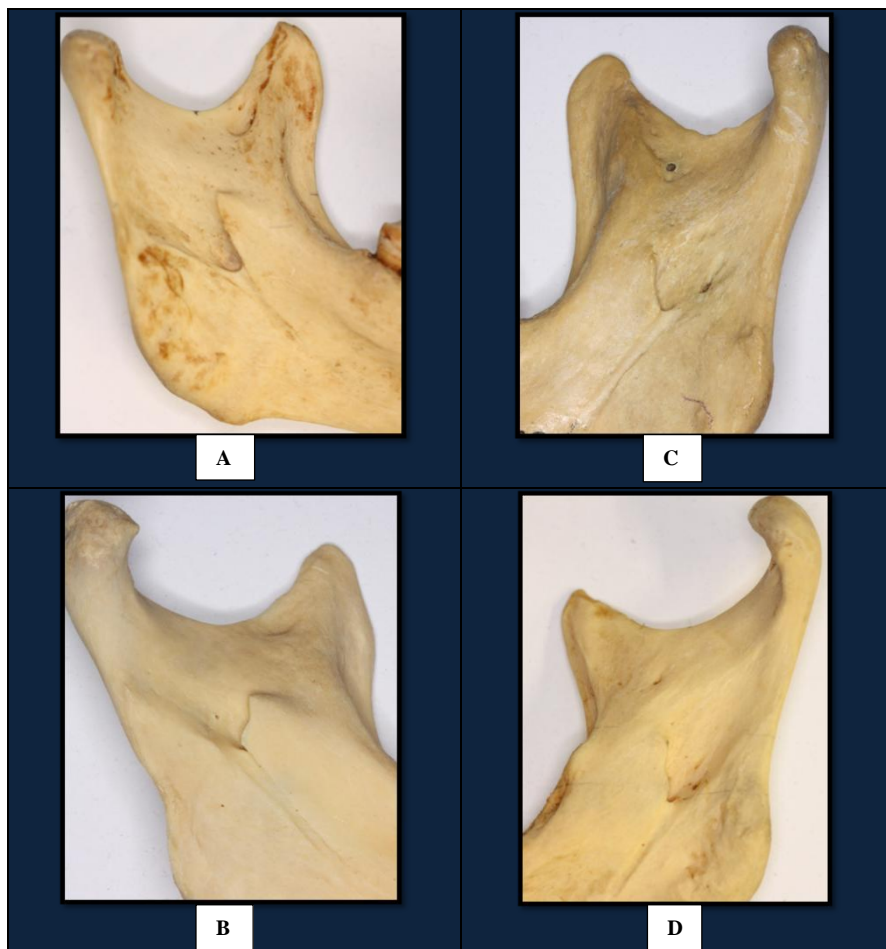


Fig 5:
Anatomical variations of the lingula.

A-Triangular

B-Truncated

C-Nodular

D- Assimilated

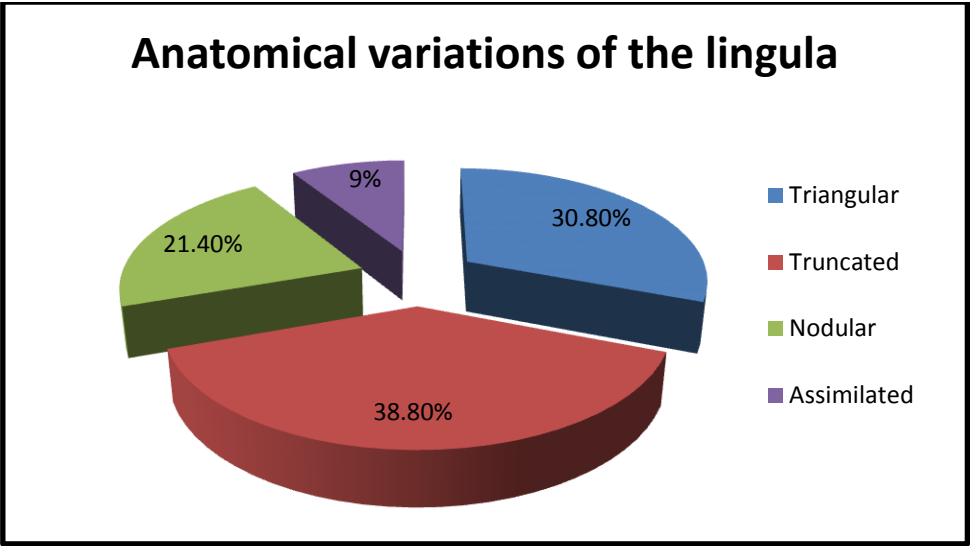


Fig 6: Incidence of the anatomical variations of the lingula

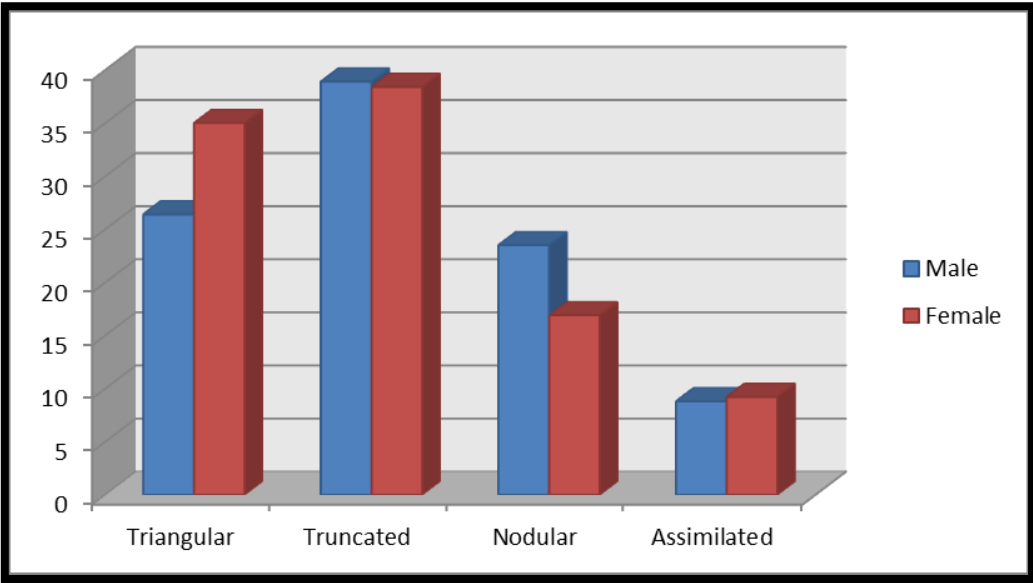


Fig 7: Percentage distribution of anatomical variations of the lingula amongst males and females

5.2 Location of the lingula in relation to ramal landmarks and the mandibular 2nd molar tooth

The position of the lingula in relation to mandibular ramal landmarks is shown in Table 1.

There was statistically no significant difference in position of the lingula between the right and left sides of the mandible in terms of the distance from the anterior border, posterior

border and sigmoid notch of the ramus of the mandible, with $p= 0.18, 0.83$ and 0.2

respectively. Measurements indicated that the average horizontal distance of the lingula from

the anterior border of the ramus of the mandible was approximately 20.42mm (right) and

19.88mm (left), the average horizontal distance from the posterior border of the ramus being

16.77mm (right) and 16.84mm (left) whilst the average horizontal distance of the lingula

from the sigmoid notch being 16.53mm (right) and 16.1mm (left).

Parameter	Average		Range		Standard Deviation		P –value (t-test)
	Right	Left	Right	Left	Right	Left	
Distance from the anterior border	20.42	19.88	12.98 to 28.08	13.09 to 27.72	2.85	2.84	$p= 0.18$
Distance from the posterior border	16.77	16.84	12.18 to 22.05	10.73 to 22.77	2.05	2.2	$p=0.83$
Distance from the sigmoid notch	16.53	16.1	9.25 to 22.74	10.33 to 20.65	2.56	2.2	$p= 0.2$
Distance of the lingula from the mandibular 2 nd molar	33.8	32.9	26.4 to 42.41	20.87 to 40.68	3.3	3.9	$p= 0.08$

Table1: Location of the lingula in relation to ramal landmarks and the mandibular 2nd molar tooth (millimetres)

The horizontal distance from the tip of the disto-buccal cusp of the mandibular second molar tooth to the tip of the lingula was found to be on average 33.8mm (right) and 32.9mm (left) (Table 1). This implies that the distance from the second molar to the posterior border of the ramus of the mandible is approximately 48mm. There was no statistical difference in measurements between the right and left sides of the mandible.

5.3 The relationship of the lingula to the occlusal plane

The positional relationship between the lingula and the occlusal plane is seen in Table 2. No statistically significant difference was observed between the right and left sides of the mandible in terms of the relationship of the lingula to the occlusal plane. In 36.3% of cases, the lingula was found to be at the level of the occlusal plane. The lingula was above the level of the occlusal plane in 63.7% of cases, by an average distance of 6.5mm (SD +/- 2.42mm) on both the left and right sides of the mandible.

	Number		Range		Average		Standard Deviation		p- value (t-test)
	Right	Left	Right	Left	Right	Left	Right	Left	
Occlusal plane									
At Level	38	35	-	-	-	-	-	-	
Above Level	68	60	2.23 to 16.06	1.8 to 14.19	6.57	6.53	+/- 2.42	+/- 2.42	p=0.86

Table 2: The relationship of the lingula to the occlusal plane

5.4 The mandibular foramen

The average width of the mandibular foramen was 4.84mm (right) (SD-1.02mm) and 4.86mm (left) (SD-1.09). There was no statistically significant difference between the right and the left sides of the mandible in terms of the average width of the foramen ($p=0.9$). The average height of the mandibular foramen measured 7.36mm (right) (SD +/-1.69) and 6.84mm (left) (SD +/- 1.9). Results indicated only a slight statistical difference in measurement between the right and the left sides of the mandible in terms height of the mandibular foramen, with the height of the foramen on the right side being slightly higher as compared to that on the left side (Table 3).

	Number		Average		Range		Standard Deviation		p-value (t-test)
	Right	Left	Right	Left	Right	Left	Right	Left	
Width	106	95	4.84	4.86	2.23 to 6.9	2.17 to 10.5	1.02	1.09	p=0.9
Height	106	95	7.36	6.84	3.62 to 11.12	2.9 to 12.75	1.69	1.9	p= 0.04

Table 3: The dimensions of the mandibular foramen (millimetres)

5.5 The position of the lingula in relation to the type of malocclusion

The lingula was found to be located above the level of the occlusal plane in 70% of class 1 occlusions, 65% of class 11 occlusions and 58% of class III occlusal relationships, with an average distance of 6.1mm (SD +/- 3.46) 7.1mm (SD +/- 4.09) and 6.5mm (SD +/- 3.2) respectively.

	Number	Lingula in relation to the occlusal plane		Average distance above the occlusal plane	Standard Deviation
		At Level	Above		
Class 1	94	28	66	6.1mm	3.46
Class11	29	10	19	7.1mm	4.09
Class111	12	5	7	6.5mm	3.2

Table 4: The position of the lingula in relation to the type of malocclusion

5.6 Racial variations in the anatomical position of the lingula

The race of the specimens was known, identified from historic records. 94 (83%) of the specimens were from Black individuals, and 19 (17%) were Caucasian. The dimensions of the ramus of Caucasian mandibles were smaller in terms of distance of the lingula from the anterior border and posterior border of the ramus of the mandible. The mean distance of the lingula from the sigmoid notch of Caucasian mandibles was greater (18.1mm) than that of the Black mandibles (16.2mm). The distance of the lingula from the distal aspect of the second molar tooth was greater in the black mandibles (34.2mm) as compared to the Caucasian mandibles (31.3mm). The average width and height of the mandibular foramen was comparable between Black and Caucasian specimens (see Table 5).

	Number	Distance from the anterior border	Distance from the posterior border	Distance from the sigmoid notch	Distance from the second molar tooth	Width of the mandibular foramen	Height of the mandibular foramen
Black	94	20.8	17.1	16.2	34.2	4.8	7.2
Caucasian	19	17.1	15.1	18.1	31.3	4.9	7.8

Table 5: Differences in the anatomical position of the lingula in Black and Caucasian specimens

6.0 Discussion

The lingula, as its name implies, is a tongue shaped projection found on the medial aspect of the ramus of the mandible. It overlies the mandibular foramen, where the inferior alveolar vessels and nerve enter into the mandibular canal, and has become an important clinical landmark to surgeons as well as dental practitioners. Knowledge of both its location and shape is imperative in order to accurately identify the structure clinically, since anatomical structures in relation to the lingula are subject to injury during a variety of oral and maxillofacial surgical procedures, such as in orthognathic surgery, mandibular trauma management, pre-prosthetic surgery and nerve injury during inferior alveolar nerve blocks.^{11,12,13,14} Failure to do so may result in an increased risk of complications related to the procedure being performed.^{12,13,14,38} This may include an increase in the occurrence of a ‘bad split’ or damage to the inferior alveolar vessels and nerve when performing a sagittal split ramus osteotomy.^{38,39,42}

For too long there has been a dearth of information regarding the shape of the lingula. Nicholson¹⁹ and Dubrul²⁰ acknowledged that various shapes may be present, but failed to describe them. Nowadays, four different shapes are recognised, namely the triangular, truncated, nodular and assimilated shapes.^{21,22,23,24}

The present study has found that the truncated type was the predominant lingula shape noted in 38.8% of cases, with the triangular type only marginally less common (30.8%), followed by the nodular (21.4%) and assimilated (8.9%) variants. The results are similar to studies conducted by Kositbowornchai et al²⁶ and Jansisyanont et.al,¹⁵ who have also found the truncated variant to be the most common types comprising 47% and 46% of the specimens respectively.. Hossain et al²⁸ only noted three variants of the lingula in his study of 208 Bangladeshi mandibles i.e. triangular, truncated and assimilated comprising 70.2%, 20.2%

and 9.6% respectively. Other studies have reported the triangular variant to be the most common.^{16,17}

In the present study the triangular and assimilated variants were more commonly found in female mandibles, while the nodular variant was more commonly noted in male mandibles. The truncated variant was noted in almost equal numbers in both males and females, with an incidence of 39% and 38% respectively. This is in contrast to Murilimanju et al,¹⁶ who found that the triangular variant was more common in males and the nodular variant more common in females. Tuli et al¹⁷ found that the truncated variant was more common in males and the nodular variant more common in females. From these results, it becomes apparent that there are wide variations in the incidence of the shape of the lingula in both males and females.

The reason for the variation in shape is unknown. Tuli et al¹⁷ suggested that since the lingula is considered a vestigial structure, serving as a point of attachment for the sphenomandibular ligament, and no tension is exerted on the structure during any movement of the jaw. It is therefore doubtful as to whether the lingula is disappearing as a process of evolution such as in the cases of the nodular and assimilated types.^{17,26} It has also been postulated that the lingula, together with other non-metric measurements of the skull, could be used as an anthropological marker to assess different populations and races.^{17,26,27} However, further investigation needs to be carried out to assess this hypothesis. Interestingly, Kilarkaje et al⁴⁹ reported that the shape of the mandibular foramen may be influenced by the shape of the lingula.

The anatomical location of the lingula in relation to ramal landmarks and surrounding structures has been found to differ amongst various population groups.^{15,19,26} Several studies have been conducted to identify the anatomical location of the mandibular foramen, with few concentrating on describing the position of the lingula to various ramal landmarks and it's

relation to the mandibular foramen. In this study we have aimed to identify the anatomical location of the lingula in dry mandibles, in order to obtain information that could be used when performing mandibular osteotomies.

Results from this study have indicated that the lingula is on average 20.15mm (20.42mm [right], 19.88mm [left]) from the anterior border of the ramus of the mandible, 16.8mm (16.77mm [right], 16.84mm [left]) from the posterior border of the ramus of the mandible and 16.3mm from the sigmoid notch (16.53mm [right], 16.1mm [left]). These results varied only marginally from those reported by Jansisyanont et al,¹⁵ but exhibited a large discrepancy from the values obtained by Kim et al.⁸ A possible explanation for the variation in results could be due to different methodology employed by the different investigators. The methodology employed in this study proved to be the most reliable and reproducible method in determining points of reference for the anatomical location of the lingula, with correlation coefficients of > 95% in both intraobserver and interobserver error tests. In addition, it is a simple method that can be used intraoperatively to gauge the possible anatomical position of the lingula.

We found that the horizontal distance from the tip of the disto-buccal cusp of the mandibular second molar to the tip of the lingula was on average 33mm (SD +/- 3.3mm). There was no statistically significant difference between the left and the right sides of the mandible. Kim et al⁸ in a similar study on Korean mandibles found that the average horizontal distance from the distal side of the mandibular second molar to the lingula tip measured approximately 28.7mm (SD +/- 2.87mm). Jansisyanont et al,¹⁵ in a study conducted on Thai mandibles, found the distance from the lingula tip to the disto-buccal aspect of the second molar tooth to be approximately 29.7mm (SD +/- 4.4mm). These studies have further shown that a possible difference exists between the anatomical location of the lingula amongst different population groups in relation to surrounding landmarks. This may be due to variation in the size of the

rami of mandibles, as noted in a study by Lee,⁵⁰ who found that Korean mandibular rami were the largest among Asians, but smaller than Caucasians. We also found that the ramus of Caucasian mandibles was smaller in the antero-posterior dimension, when compared to black mandibles. Further studies, with larger samples, need to be carried out to validate these findings. When performing surgery, or other procedures, on the ramus of the mandible, it appears that an understanding of population variations may be essential in preventing complications.

There are few studies in which the position of the lingula was evaluated with respect to the level of the occlusal plane.^{8,15} Most studies have reported on the position of the mandibular foramen in relation to the occlusal plane.^{7,18,19,26} Whilst anatomical relationships and measurements of the mandibular foramen are invaluable, it is often not easily visualised intraoperatively, and is therefore less likely to be considered a clinical landmark. The lingula, however, can be readily visualised intraoperatively, given one has a good understanding of its anatomical location, and therefore is regarded as a better clinical landmark. In this study, results indicated that the lingula was most commonly located above the level of the occlusal plane (63.7% of cases), which is similar to several other studies.^{8,15} Although there was no statistically significant difference between the right and the left sides of the mandible, it is important to note that in some instances, the level of the lingula in relation to the occlusal plane differed from side to side within the same mandible. The average distance above the level of the occlusal plane was 6.5mm (SD +/- 2.42mm), which is higher than that reported by Jansisyanont et al,¹⁵ where it was found to be approximately 4.5mm (SS +/- 2.6mm) above the level of the occlusal plane. Interestingly, in this study, there were no incidences in which the lingula was located below the level of the occlusal plane. The results from a study conducted in Thailand found that in 80% of cases, the lingula was located above the level of the occlusal plane, while in 20% of cases it was located below the level of the occlusal plane

and in no incidences was the lingula found to be at the level of the occlusal plane.¹⁵ From these studies we were able to conclude that the level of the lingula in relation to the occlusal plane varies among individuals and can also vary from side to side within the same individual.

With regard to the mandibular foramen, our study found that the average width of the mandibular foramen was 4.8mm and the average height was 7,1mm. There was statistically no significant difference in width between the right and left sides of the mandible ($p=0.9$), and only a slight statistical difference in height between the right and left sides ($p=0.04$). A great degree of variation was observed in terms of the width and height of the mandibular foramen, evident from the range of measurements calculated. The width of the foramen ranged from 2.17mm to 10.5mm, and the height of the foramen ranged from 2.9mm to 12.75mm, highlighting the degree of variation in both width and height.

There are several reports concerned with the anatomical position of the mandibular foramen in relation to the ramus of the mandible.^{7,18,19} These studies have aimed to identify the location of the mandibular foramen, the width and height of the foramen, and in some cases, its relation to the lingula of the mandible.

Nicholson¹⁹ concluded that because of the variability in the position of the mandibular foramen in East Indian dry mandibles, little information could be gained from his anthropometric study that would improve the definition of the location of the foramen and assist clinicians wishing to anaesthetize the inferior alveolar nerve. Mbajjorgu¹⁸ also found that the position of the mandibular foramen on dry adult Zimbabwean mandibles was highly individualistic, evident by the range of variation in the measurements of the individual mandibles. The mean height of the foramen of the right and left sides of the mandible was 8.38mm, which is higher than the mean height of 7.1mm recorded in the present study.

According to Mbajjorgu,¹⁸ the implication of the measurement of the height of the lingula i.e. the height of the mandibular foramen, is that the inferior alveolar nerve disappears into the mandibular foramen at a variable distance from the tip of the lingula. Results from this study indicate that the assumption that the lingula and the mandibular foramen are approximately on the same level above the occlusal plane is not true, which was also noted by Hayward et al²⁹ in their study conducted to determine the position of the mandibular foramen.

There is currently paucity in the literature regarding the position of the lingula in relation to the type of malocclusion. In this study, an attempt was made to identify possible discrepancies in the anatomical position of the lingula that may be related to the type of malocclusion. The occlusal relationships were divided according Angle's classification method. Results indicated that in 70% of class I occlusions, 65% of class II occlusions and 58% of class III occlusal relationships, the lingula was found to be above the level of the occlusal plane, with an average distance of 6.1mm, 7.1mm and 6.5mm respectively. In this study the highest position of the lingula was noted in class II followed by class III malocclusions. This suggests that a higher position of the lingula should be anticipated in both class II and class III malocclusions. The small sample size of both these types, however, precludes meaningful comparisons between them.

Several studies have found that if the lingula is situated high on the mandibular ramus, the medial horizontal osteotomy is made higher on the mandibular ramus in a thin region where there is little or no cancellous bone.^{9,32,33,34} According to Cillo and Stella,³⁶ in Class III malocclusions, the lingula was found to be higher than in Class I and Class II malocclusions, the ramus of the mandible exhibited limited marrow and the inferior alveolar nerve was found to be near the inferior border of the mandible. All these factors increase the risk of occurrence of an unfavourable fracture and IAN injury. Class III malocclusions are therefore regarded as having the greatest risk of acquiring an unfavourable fracture, due to the high lingula.³⁶

However, according to a recent study in which 2005 sagittal split osteotomies were reviewed, 14 cases resulted in unfavourable fractures.⁵¹ The authors concluded that these unfavourable fractures could not be correlated to a particular type of dental-facial deformity, or skeletal class according to Angle's classification.⁵¹ Further research is required to determine the position of the lingula in various occlusal relationships and the possible effect it may have in determining the location of the medial horizontal osteotomy in sagittal split ramus osteotomies.

Due to its relationship to the mandibular foramen, the location of the lingula is essential when performing the medial horizontal osteotomy in the mandible. The initial technique described by Obwegeser and Trauner in 1957¹ involved extensive soft tissue dissection and a horizontal osteotomy on the medial and lateral aspect of the ramus of the mandible that extended to the posterior border. This technique has been modified over the years by several investigators in an attempt to reduce the associated complications.^{3,4,6,34} Hunsuck⁴ modified the technique by reducing the extent of the osteotomy of the cortical bone on the medial surface of the ramus to immediately posterior to the mandibular foramen. No single modification is superior to another. The surgeon has to decide the appropriate osteotomy that takes into account some of the factors that might determine the type of technique, such as position of the lingula and mandibular foramen.

The location of the lingula is essential when performing the medial horizontal osteotomy. Understanding the distance from the ascending ramus to the lingula is a crucial guide to the placement of the medial horizontal osteotomy. This osteotomy line should ideally extend a few millimetres posterior to the lingula, and thus the mandibular foramen, to ensure a favourable fracture and to prevent damage to the inferior alveolar vessels and nerve. Also, knowledge of the distance from the lingula to the sigmoid notch is important as well, as performing an osteotomy too far superiorly above the lingula may place the horizontal medial

osteotomy completely in cortical bilaminar bone, which may increase the risk of an unfavourable fracture.^{9,33,36} Smith,⁹ in his attempt to determine the point of fusion between the cortical plates of the ramus of the mandible, found that at a distance of 7.5mm to 13.3mm above the lingula, buccal and lingual cortex fusion occurs at a rate of approximately 20% and 39% in the anterior and posterior parts of the ramus respectively. Other studies have reported similar results.^{33,52} The recommendation made by these authors was that the medial horizontal osteotomy be placed at or just above the level of the tip of the lingula in order to ensure that the osteotomy be placed in cancellous bone and a favourable fracture is obtained.^{9,33,36} Placement of the horizontal osteotomy at a distance of greater than 5mm above the level of the lingula increases the risk of an unfavourable fracture and damage to the inferior alveolar vessels and nerve.^{36,52}

In the case of a high lingula, such as is sometimes observed in class III malocclusions, some authors have described techniques that aim to place the medial horizontal osteotomy in cancellous/ spongy bone, thereby reducing the risk of an unfavourable fracture.^{36,53} Cillo and Stella³⁶ have suggested that in such cases the osteotomy be angled from its typical location in the mid-ascending ramus up to the lingula. If cancellous bone is still not encountered, the authors suggest that the medial cut be widened from anterior to posterior at the expense of cortex along the inferior aspect of the osteotomy until cancellous bone is seen. Nishioka and Aragon⁵³ suggested that in the case of a high lingula, two medial osteotomies be made, one above the lingula and one below the lingula. These are connected by the vertical osteotomy. He believed that this technique may decrease the risk of an unfavourable fracture in high lingula cases. However, placement of a medial osteotomy below the level of the lingula drastically increases the risk of damage to the inferior alveolar vessels and nerve.

Based on this study, we suggest the following rule to help describe the lingula in relation to the surrounding structures: the 3:2:1:1 rule of 16. It is as follows:-

- 3 X 16 = the distance from the second molar tooth to the posterior border of the mandible (48mm)
- 2 X 16 = the distance from the second molar to the lingula
- 1 X 16 = the distance from the sigmoid notch to the tip of the lingula
- 1 X 16 = the distance from the lingula to the posterior border of the mandible

Alternatively, we have also devised the 5:4:4 rule of 4. It is as follows:-

- 5 X 4mm = 20mm :the distance from the anterior border to the ramus of the mandible
- 4 X 4mm = 16mm : the distance from the sigmoid notch to the tip of the lingula
- 4 X 4mm = 16mm : the distance from the lingula to the posterior border

The above rules may serve as guidelines to help locate the lingula more proficiently intraoperatively.

7.0 Conclusions

The shape and metric characteristics of the lingula in relation to surrounding structures in South Africans vary from other populations. The average distance of the tip of the lingula from the anterior border, posterior border and sigmoid notch the ramus of the mandible was approximately 20.15mm, 16.77mm and 16.3mm respectively. This data may assist surgeons to localize the lingula and avoid intraoperative complications when performing a SSRO.

The truncated variant of the lingula was observed most commonly, followed by the triangular, nodular and assimilated shapes. Males were more likely to exhibit a truncated shaped lingula, whilst females were more likely to exhibit a triangular shape. Knowledge of the various shapes of the lingula may assist the surgeon to readily identify the structure intraoperatively, limiting both the amount of time and exposure required to identify the structure. This may ultimately lead to fewer complications.

The average distance of the tip of the lingula from the mandibular second molar tooth was found to be 33.3mm. The mandibular second molar tooth may be used as a clinical guide for the location of the lingula when performing surgery on the medial aspect of the ramus of the mandible.

In the majority of cases (63.7%), the lingula was found to be above the level of the occlusal plane by an average distance of 6.5mm.

The width and height of the mandibular foramen is highly variable. Results from this study indicate that the lingula is on average 7.1mm superior to the base of the mandibular foramen. Thus, by performing the medial horizontal osteotomy cut at the level of the lingula, or just superior to it, may lead to avoidance of the inferior alveolar neurovascular bundle.

The lingula was found to be most superior, with respect to the level of the occlusal plane, in Class II malocclusions (average distance of 7.1mm). This was found to be contradictory to the assumption that class III malocclusions presented with a high lingula. The small sample size may be the reason for the discrepancy in findings.

The dimensions of the ramus of Caucasian mandibles were smaller in terms of distance of the lingula from the anterior and posterior borders of the ramus of the mandible.

However, Black mandibles exhibited, on average, a shorter distance from the deepest point of the sigmoid notch to the tip of the lingula. This finding may have implications on the position of the medial horizontal osteotomy cut. However, further investigation is required to determine if fusion of the buccal and lingual cortices of the ramus of the mandible occurs at a lower level in Black mandibles as compared to Caucasian mandibles.

When applied to SSRO operations, the anatomic data provided by this study may assist surgeons to locate and identify the lingula without difficulty, and avoid intraoperative complications. The data presented has a direct relevance to clinical practice and teaching.

A thorough understanding of the anatomy of the lingula and its surrounding structures is essential when performing a sagittal split ramus osteotomy.

8.0 References

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Appendix 1: Data Collection Form

A. Number (refers to Specimen number): _____ -

Age: _____

Sex: _____

Race: _____

	Right	Left
Shape (of the lingula)		
Width of the foramen		
Height of the foramen		
Distance of the lingula from the mandibular notch		
Distance of the lingula from the anterior border of the mandibular ramus		
Distance of the lingula from the posterior border of the mandibular ramus		
Position of the lingula in relation to the occlusal plane: -above/ below/ at level		
Distance of the lingula from the occlusal plane		

Appendix 2: Ethics Waiver

University
of the Witwatersrand,
Johannesburg



Human Research Ethics Committee (Medical)
Medical Research Ethics Committee for Research on Human Subjects (Medical)

Postal Address: Research Office, Room SH10005, 10th floor, Senate House • Telephone: +27 11 717-1234 • Fax: +27 11 339-5708
Post Office Bag 3, Wits 2050, South Africa

Ref: W-CJ-101109-1

09/11/2010

TO WHOM IT MAY CONCERN:

Waiver: This certifies that the following research does not require clearance from the Human Research Ethics Committee (Medical).

Investigator: School of Anatomical Sciences (Head: Prof T J M Daly).

Project title: Research on cadaveric material.

Reason: In terms of Chapter 8, sections 62-64 of the National Health Act No 61 of 2003 donated bodies and their tissues may be used for, among other purposes, health research. Use of such material is subject only to permission from the responsible person in the School of Anatomical Sciences - the Head or person designated by the Head.

A handwritten signature in black ink, appearing to read 'Peter Cleaton-Jones'.



Professor Peter Cleaton-Jones
Chair: Human Research Ethics Committee (Medical)

copy: Anisa Keshav, Research Office, Senate House, Wits