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A COMPARATIVE STUDY OF THE PTERYGOPALATINE FOSSA AND ITS GANGLION IN A SOUTH AFRICAN SKELETAL AND CADAVER POPULATION

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Declaration:

I Maira du Plessis, hereby declare that this dissertation is based on my own work (except where acknowledgements indicate otherwise). It is being submitted in fulfilment of the degree of Master of Science in Anatomy, at the University of Pretoria. It has not been submitted for any other degree or examination at this or any other University.

Signed

……

M du Plessis

On the.....day of.....2008

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Abstract

Blocking the contents of the pterygopalatine fossa (PPF) is a highly effective method in alleviating pain in trigeminal neuralgia (TN) and other facial pain syndromes. This, however, is not a widely used technique, due to the difficulty in locating the PPF which is obscured by bony and soft tissue structures. Despite the various unspecific techniques that have been attempted, in many cases radiography still seems to be used as it is the most effective method in locating the PPF. The aim of this study was therefore to achieve a safe and alternative method of locating the PPF including its contents without the aid of radiography. A total of 160 skulls from the Pretoria Bone Collection at the University of Pretoria were used. Distinct anatomical landmarks and the use of existing and new anthropometric measurements were used to define the location of the PPF in any individual. Regression analysis provided the strength of influence each measurement had on the location of the PPF. From the results, two mathematical formulae were devised (one for each side). These formulae were tested on 47 cadavers by substituting the measurements of each individual into the created formulas. A needle was then inserted at the calculated points, and the area around the needle dissected to determine whether or not it was in the PPF. Our results showed an accuracy of 65.22% on the right and 54.35% on the left. It is hoped that this new technique will aid researchers and clinicians alike in the management of various pain disorders as well as pain management during surgery.

Opsomming

Daar is bevind dat ‘n lokale verdowingsblok van die inhoud van die pterygopalatine fossa (PPF) die pyn effektief verlig vir trigeminale senuweepyn, sowel as ander pyn sindrome. Die tegniek word egter nie gereeld gebruik nie as gevolg daarvan dat dit moeilik is om die PPF te betree deurdat dit deur verskeie benige en sagte weefsels verberg word. Die literatuur beskryf verskeie onspesifieke metodes om die prosedure uit te voer, maar in die meeste gevalle moes radiografie gebruik word om sukses te behaal. Die doel van hierdie projek was om ’n alternatiewe metode te ontwikkel wat veilige en effektiewe toegang tot die PPF bied, sonder om radiografie te gebruik. ’n Totaal van 160 skedels was gebruik om anatomies landmerke en bestaande sowel as nuwe antropologiese metings te maak. Regresie analise het die sterkte van die invloed van die onderskeie metings met die pterygopalatine fossa gemeet. Vanuit die resultate van die statistiese analise is twee formules ontwerp (een vir elke kant van die gesig). Die formules was getoets op 47 kadavers deur die metings vir elke individu in die formules te plaas. ‘n Naald is dan geplaas in die uitgewerkte punt, die area om die naald was gedisekteer om te sien of die naald in die fossa en dus by die ganglion was of nie. Die resultate toon ‘n akkuraatheid van 65.22% aan die regterkant en 54.35% aan die linkerkant. Daar word gehoop dat hierdie nuwe tegniek ‘n effektiewe manier van pyn behandeling word in verskeie pyn sindrome sowel as gedurende chirurgie vir beide navorsers en chirurge.

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1. Introduction

There are numerous classifications of pain, but in general it can be defined as an unpleasant sensation localised to a part of the body with actual or potential tissue damage. This pain process is mediated by specific nerve fibres to the brain where it is perceived and altered by various factors.[1-3] Pain is often an early sign of morbidity and individuals often tend to relay the experience of pain to the existence of a diseased state.[4] Usually pain is only considered when dealing with diagnosis and treatment of disease. However, the impact of pain on daily activities should be considered independently as well.[3,5] One of the worst and most challenging experiences anyone could have is that of chronic or persistent pain, especially when it is periodic and unpredictable as in the case of trigeminal neuralgia.[6-8] Chronic pain and especially pain caused by trigeminal neuralgia can and does interfere with activities of normal daily living.[8, 9]

Of all diseases related to the fifth cranial nerve, trigeminal neuralgia, previously known as *tic douloureux*, is considered to be the most important. It is also known to be the most common neurological cause of pain in the orofacial area.[10-14] Trigeminal neuralgia symptoms are described as episodes of extreme (unbearable) pain in the distribution areas of one or more of the trigeminal divisions which is independent of any motor or sensory loss.[10-12,15-18] Minor activities such as facial movement, talking, cold temperatures or even a small breeze across the face can trigger a trigeminal neuralgia attack.[8,14,19] Trigeminal neuralgia is a painful disease that can and usually does decrease the quality of life. Individuals who have shown symptoms of trigeminal

neuralgia usually avoid things that cause attacks. In some cases the individuals commit suicide when no relief of pain is achieved.[20]

There are numerous ways of treating trigeminal neuralgia, all of which are aimed at relieving pain. These treatments cover a wide range and include pharmaceutical as well as surgical forms of pain relief. The effectiveness of each treatment depends on various factors such as the age of the individual and time lapse between the experience of the first symptoms and its treatment. A review of the literature illustrates that deposition of anaesthetic fluid in the vicinity of the pterygopalatine ganglion effectively alleviates trigeminal neuralgia pain.[21] There are various approaches that have been described in the literature for performing, what has been referred to as, a pterygopalatine block. None of the described techniques are very specific, neither do they provide specific anatomical landmarks.[21] Although reported to be highly effective in the relief of pain, the pterygopalatine block, interestingly, is not commonly used.[19] There are three intra-oral and three extra-oral techniques described in the literature for blocking the nerves associated with the pterygopalatine fossa. These are described below.

In the intraoral techniques, the needle may

a) be passed through the greater palatine foramen up the palatine canal and into the pterygopalatine fossa. This technique has been described in relation to injecting the pterygopalatine or trigeminal ganglions for the treatment of neuralgia.

b) reach the same location by following the outer surface of the bony structure of the upper jaw. In this case the needle is introduced along the line of junction of the pterygoid process of the sphenoid bone with the tuberosity of the maxillary bone.

c) be passed obliquely along the outer surface of the maxilla until it reaches the pterygopalatine fossa.

All of the above-mentioned intraoral techniques are difficult to perform and only skilled professionals are able to achieve appropriate anaesthesia.

In the extra oral techniques, the needle may

a) be "passed just below the middle point of the zygomatic arch, through the masseter muscle, which obliterates the sigmoid notch of the ascending ramus of the mandible." The needle is introduced in a transverse manner towards the base of the pterygoid process, that serves as a deep landmark. At this point it is passed forwards into the pterygopalatine fossa.[22]

b) be inserted at an angle formed by the anterior border of the coronoid process of the mandible and the malar (cheek bone). It is then advanced along the lateral and posterior surface of the maxilla.

c) be placed above the zygomatic arch. This last technique is poorly described and makes little sense.[22]

The pterygopalatine ganglion gives somatosensory effects via the facial and trigeminal nerves. It has visceral motor functions through its parasympathetic and sympathetic innervation via the superficial and deep petrosal nerves respectively. The main sensory distribution of the pterygopalatine ganglion is to the orbit, nose, palate and buccal mucosa. However, the effect of a pterygopalatine block has been shown to extend to adjacent head and neck areas.[21] The pterygopalatine ganglion is said to be linked to a sympathetic reflex arc between the head and spinal cord assisted by its anatomical location in the pterygopalatine fossa.[21]

Therapeutic effectiveness has been claimed in various diverse cases including: facial pain, neck pain, cluster headaches, as well as lower back pain, hyperthyroidism and menstrual pain.[21] Review of the literature and personal correspondence with medical practitioners in the field revealed that locating the pterygopalatine fossa and ganglion in patients was extremely problematic and often required the aid of radiography. The current study was therefore aimed at developing a way in which the fossa could be located in any individual without having to subject the patients to unnecessary radiation. The study included anatomical structures that surround the pterygopalatine fossa and that could be easily located on a living individual.

2. Aims and Objectives

1. The first aim of this study was to define and quantify the location of the pterygopalatine fossa in adult human skulls.

2. The second aim was to use the data collected from the first aim to determine whether differences in the location of the pterygopalatine fossa exists between the various age, sex and population as well as between the right and left sides of the face.

3. The third aim of this study was to devise a formula or formulae (depending on the results of the data collected) for estimating the anatomical location of the pterygopalatine fossa in any given individual by using demographic information together with measurable bony landmarks.

4. The fourth aim was to apply the formulae developed from the skeletal material to cadavers to verify whether the pterygopalatine fossa and ganglion could be located in this manner.

3. Literature Review

3.1 Pain

There are only a few illnesses that do not contain a painful phase and in cases like these, diagnosis is always doubtful.[4] The existence of pain not only causes discomfort to the patient but, because people have different perceptions of what pain indicates, physicians are challenged with complaints of mild to severe pain of which many do not have an underlying disease.[3,4] In some instances, patients often seek treatment for the pain only or expect diagnosis when no other symptoms are present.[3,4] It has also been stated that pain has an emotional as well as a physical component and this duality further complicates its understanding and interpretation.[3,4]

There are several pain receptors throughout the body that react to injury.[2] These receptors respond to pain by sending messages to the brain through electrical signals called impulses.[2] In some cases the pain impulse triggers a reflex response, which causes muscles to contract in order to move the body or part of the body away from the cause of the noxious impulse. In general, pain is influenced by a series of factors which are classified as being biological, psychological and social in origin.[6] It can also be said that these factors have an effect on the pain as well.[6]

Pain can be divided into two main types:

a) Acute or sudden onset pain that is usually caused by an external source and normally lasts for a short period.
b) Chronic pain that is generally caused by a source within the body and is of long or permanent duration.[1]

Pain can be experienced in numerous ways, such as sharp or dull, constant or periodic, throbbing or steady and this makes it difficult to describe. The intensity of pain can range from mild to unbearable and can be spread over a small or large area.[2,3] Additional words for expressing the experience of pain such as burning, stabbing, twisting or other terms related to tissue-destructive processes. Emotional reactions such as nauseating or sickening are also used to describe pain.[3]

The ability to tolerate pain, including how the pain is experienced, is very much dependent on factors such as the personality and mood of the individual.[2,6,9,23,24] Perception of pain may be affected by additional factors other than the cause of the pain. For example, a child who had hurt his foot might only realise the injury and start crying after seeing the blood. Thus, regardless of its severity, the degree of pain can be related to circumstances leading to the injury, as seen in the example just given.[2,4,6,9,23] This can be described by using the term somatosensory amplification and explains the way in which maladjustive cognition (awareness) can lead to an increased perception of pain.[25]

The ability to tolerate pain varies greatly with age. For example, it has been reported that old people are more stoic (indifferent to situations or emotions) than young people and they tend to complain less of pain.[2] Acute pain is often associated with heightened physiological and stress reactions such as increase in blood pressure, heart rate, as well as increased local muscle contraction.[3] Dealing with chronic pain is not simply a matter of tolerance, but relies greatly on the patients' psychosocial health.[3,6,24,25]

3.1.2 Facial pain

Facial pain is usually caused by local pathology such as infection or inflammation in the orofacial region, including the teeth and surrounding structures. Chronic pain related to the face is usually associated with musculoskeletal or neurological systems. When facial pain cannot be ascribed to a specific pathological condition or the underlying cause cannot be established, it is referred to as atypical facial pain.[26] However, the term atypical pain has been omitted from the International Association for the Study of Pain (IASP) classification because most “atypical” pain is considered to be of either vascular or neuropathological origin.[26] Orofacial pain is a common complaint and forms 40% of all chronic pain, for each type of facial pain, several different aetiologies can be involved.[27,28] Chronic orofacial pain is the first and often only complaint with underlying cranial disorders.[29]

Temporomandibular disorders, headaches and neurological disorders are the three major contributors to orofacial pain.[28] Temporomandibular disorders is a collective term for describing various pain syndromes including musculoskeletal disorders of the masticatory system.[28,29] Muscular disorders result in muscular tenderness on palpation and in some instances may be associated with certain headaches.[27] Most musculoskeletal disorders are not yet fully understood and in the case of chronic masticatory myalgia and fibromyalgia, as well as several other discorders, the cause is believed to be associated with the central nervous system.[28,30,31] Muscular disorders can be caused by a variety of factors such as nail biting, teeth clenching, tongue thrust, and sustained muscular contraction.[27] The aetiology of musculoskeletal disorders, including fibromyalgia, are multifactoral in nature making it difficult to diagnose and

treat.[28,29] Bruxism is considered to be a combination of clenching and grinding activities which can occur during sleep or when the individual is awake. Coupled with muscle fatigue, it is considered to be linked with facial pain associated with temporomandibular disorders.[31] Another cause of facial pain is oral cancer which, together with many others, has numerous possible causes as well as effects.[32]

The different pain disorders often overlap with regards to distribution and symptoms, making it difficult beyond measure to diagnose, let alone treat.[33] Facial pain is classified as follows:

a) *Neuralgias*: Presence of sudden sharp aching or burning and stabbing pain that lasts from a few seconds to less than two minutes. This pain recurs at short intervals and is often triggered by sensory or mechanical stimuli.[29]
b) *Facial pain syndromes with cranial nerve symptoms*: This group of syndromes is classified by presence of pain, as well as appearance of cranial lesion signs. It differs for each cranial nerve with regards to symptoms and clinical tests.[29]
c) *Trigeminal autonomic cephalgias*: This represents a group of relatively uncommon headache syndromes that are characterised by unilateral short bursts of pain along the course of the first division of the trigeminal nerve. This is often associated with other signs such as eyelid oedema, rhinorrhoea and over stimulated lacrimation.[29]
d) *Pure facial pain without involvement of neuralgias*: This is mostly pain caused by sinusitis, temporomandibular muscular disorders, disorders of

oral structures or salivary glands, referred pain, persistent idiopathic facial pain and facial syndromes of unknown or miscellaneous cause.[29]

3.2 Trigeminal neuralgia

Trigeminal neuralgia was first described by Aretaeus of Cappadocia in the 2nd century AD, the same person who defined migraine.[15] The second physician to describe similar symptoms was an 11th century Arabian doctor, by the name of Jujani, who described it as being a unilateral pain originating from the area close to the nerve and artery.[15] John Fothergill was the first to publish an article about trigeminal neuralgia in 1773 and presented it to the Medical Society of London.[15] The low occurrence of approximately 3,5-4,5 per 100 000 people is far outweighed by the severity of the pain experienced.[10,12,13,16] There are several different ways of explaining the pain felt during these sudden attacks of trigeminal neuralgia and it could even include a burning sensation or shock-like feeling.[12,15] Some patients display symptoms of hypoesthesia (loss of sensation) although it is fairly uncommon.[19] The periods between attacks are often marked by the presence of a lingering deep aching pain.[8] The affected branch of the trigeminal nerve can go into what is called a refractory period. This is a time in which it does not respond to triggers or become asymptomatic.[19] It has also been found that anaesthetic blocking of the nerve prevents both the sensory triggering as well as the pain sensation.[19]

Trigeminal neuralgia is most often unilateral and occurs twice as often on the right than on the left side of the face.[10,12] It also occurs more frequently in female patients.[12,16,19] The onset of trigeminal neuralgia in most patients is between forty and fifty years of age,[12,16,19] although some paediatric patients have shown similar

symptoms.[11] There are many different causes of trigeminal neuralgia. One can even say it is an idiopathic disorder and symptomatic patients make out only about two percent of all trigeminal neuralgia patients.[12,13,16,33] It has been proposed that trigeminal neuralgia have similar pathophysiology to that of cluster headache.[19] There are a few theories that have been tested and it is postulated that 80-90% of all trigeminal neuralgia are related to compression of the nerve root by the superior cerebellar artery, although the right sided dominance makes this theory doubtful.[8,10,12,34,35]

Another theory on handedness proposed that the quality of dental care or lack thereof due to right handed brushing of teeth is the cause of the neuralgia dominance on the right.[10] However, in 1971 it was found that the dominant side has a higher tolerance to pain, contradicting the 'twice as much on the right side' theory.[36] Trigeminal neuralgia could even be a symptom of underlying central nervous system disease.[16] Another theory is that the dimensions of the foramina differ from left to right. This replaces the vascular compression theory, unless the vascular compression causes structural changes in the nerve itself.[10,12] Some evidence exists that the dimensions of the foramen ovale is irregular and that in 75% of cases, the foramen rotundum is larger on the left than on the right.[10] If the nerves are equal in size on both sides, size differences in the foramina could explain the higher occurrence of trigeminal neuralgia on the right. Differences in nerve size have been shown in studies done on trigeminal neuralgia. However, no literature is available on the normal dimensions of these nerves.[37]

Patients with multiple sclerosis that only experienced trigeminal neuralgia on the right side often display trigeminal lesions on both sides during autopsy. Vascular

compression might be the major cause of trigeminal neuralgia, but is certainly not the only one. Other factors such as tumours, demylination and arachnoid cysts make up for about 10% of cases.[10,11,15,17,38] The cause must be determined before treatment is started to ensure that the pain does not return.[10,11,15,17,38] Trigeminal neuralgia frequently involves the mandibular and maxillary divisions of the nerve with the ophthalmic division contributing approximately two percent.[13,19,39]

3.2.1 Diagnosis and treatment of trigeminal neuralgia

Diagnosing trigeminal neuralgia is not too difficult, providing that there are no other cranial neuralgias present such as glossopharyngeal, nervus intermedius, superior laryngeal nerve, occipital neuralgia or geniculate neuralgia.[12,15] These neuralgias produce similar symptoms and can complicate the differential diagnosis. Although no clinical test exists that is specific for the diagnosis of trigeminal neuralgia, a routine clinical examination is preferable and includes testing of cranial nerve function to narrow down the possibilities.[12,15] Many physiological methods of diagnosing trigeminal neuralgia have been postulated, but none have proved to be effective. It is suggested that, if the cause of pain cannot be established during clinical examination, further investigations such as MRI or CT scans should be considered, especially when dealing with typical symptoms.[15, 35]

A helpful characteristic of trigeminal neuralgia is that it can and is known to go into remission. However, with progression, attacks tend to occur more frequently and the pain is more severe.[12,13,16] The time of day when attacks occur can be helpful in diagnosis, as trigeminal neuralgia can occur at anytime, but rarely during sleep.[12] For patients suffering from this affliction, unlike those suffering from any other pain

syndrome, total relief of pain is a must[18] and there are various treatments.[11] There are four groups of treatment, namely pharmacological, surgical, percutaneous and radiosurgical.[11,15,17] Additional treatments include radio frequency gangliolysis, glycerol gangliolysis, balloon compression, stereotactic radiosurgery, peripheral neurectomy and cryotherapy.[15] Regional nerve block therapy has been tried using local anaesthetic solutions, but the efficacy could not be measured due to the short period of analgesia.[15]

Unless patients exhibit sensitivity to anticonvulsant drugs, or have a medical condition with which the drugs will interfere, the first line of treatment is pharmacological.[11,12,15,17,35] If the patient does not respond to this, or is not satisfied with the result, alternative treatment must be considered. At this point the cause of the neuralgia becomes of utmost importance.[11,12,35] If the cause of pain is due to the superior cerebellar artery compressing the nerve, microvascular decompression surgery is the next choice.[12,17,35] Microvascular decompression of the nerve is performed via a retromastoid craniectomy and placing a Teflon pledglet at the point where the vessel and nerve come in contact with one another in order to separate them.[11] The success rate for microvascular surgery is reported to be 90% and implies full cure. Nonetheless, even though the aim is complete pain relief, a few problems still remain.[11,12,39,40]

One of the obstacles is the time at which the surgery is performed. The best results are obtained when done very soon after the first symptoms appear.[40] Many factors influence the outcome of surgery and in some cases it only alleviates the pain.[40] Complications of microvascular decompression surgery must not be neglected. The risks are numerous and include hearing loss, permanent facial anaesthesia, brainstem infarction, cerebellar injury, dyssynergia (inability to control voluntary muscles),

meningitis, headaches and even death.[12] Radiosurgery is a new, but effective technique for treatment of trigeminal neuralgia. It is aimed at making lesions on the trigeminal nerve using a gamma knife and 201 gamma rays that are generated by cobalt 60 ions (Co^{60}), resulting in pain relief.[11,17] It is the least invasive procedure, with a success rate of 85% for complete or partial pain relief after one year.[11]

Percutaneous treatments act in interrupting the pain signal by damaging the neural pathway. This includes thermal lesioning, glycerol injections, as well as balloon compression.[11,17,35] These treatments have a lower success rate, can cause motor dysfunction and are only performed if patients refuse surgery, or if surgery was unsuccessful.[11,12] Percutaneous treatments result in temporary pain relief and repeat block can cause permanent facial numbness.[12] Aryan and co-workers reported in 2006 that many patients prefer the percutaneous treatments despite the availability of more advanced methods claiming better results.[17]

3.3 Anatomy

Knowledge of the anatomy of the skull, as well as the surrounding tissue, is essential when attempting facial pain management. To reduce the amount of trauma during any procedure, as well as to limit invasiveness, it is fundamental that the anatomy is understood.[41] The facial bones consist of the maxilla, frontal, zygomatic, mandibular and nasal bones, all serving as attachment for muscles and fascia.[42] Two groups of muscles are found on the face and they are divided according to function. The innervation of these muscles also differs according to their embryological development.[42,43]

The muscles of mastication are responsible for moving the mandible. They include the masseter, temporal, and the medial and lateral pterygoid muscles.[42] The muscles providing facial expression form the second group and include the remainder of the facial muscles.[42] They act as sphincters or dilators round the eye and mouth[43] and are all innervated by branches of the facial nerve. The motor and sensory innervation to the muscles of mastication is provided by the mandibular division of the trigeminal nerve.[42] The sensory innervation to the rest of the face is provided by the ophthalmic and maxillary divisions of the trigeminal nerve.[42] The skull consists of two parts, the neurocranium containing the brain and the viscerocranium forming the face.[44]

The face develops primarily from five facial primordia that appear as prominences around the stomodeum (the future oral cavity).[44] These five primordia consist of a single frontonasal, paired maxillary and paired mandibular prominences.[44] The facial prominences are derived from the first pharyngeal arch and together with the second pharyngeal arch gives rise to the facial skeleton and its accompanying soft tissue.[44,45] The first arch gives rise to the maxillary and mandibular processes from the dorsal and ventral parts of the arch respectively.[44,45] From the maxillary process the maxilla, zygomatic bone and squamous part of the temporal bone is formed.[44,45] The mandibular process gives rise to the mandible from the condensation of Meckel's cartilage.[44,45] Meckel's cartilage disappears and forms the sphenomandibular ligament. The dorsal part of the mandibular process, together with the second pharyngeal arch, gives rise to three ear ossicles, namely, the incus, stapes and malleus.[44,45]

The muscles of the face are also derived from these pharyngeal arches. The muscles of mastication, anterior belly of digastric, mylohyoid, tensor tympani and tensor veli palatini are all innervated by the mandibular branch of the trigeminal nerve and are all from the first arch.[44,45,46] The muscles formed by the second arch are, the muscles of facial expression, posterior belly of digastric, auricular, stapedius and stylohyoid.[44] The innervation of these muscles is provided by the facial nerve.[45]

The lateral aspect of the skull can be divided into three zones, namely the lateral face anteriorly, the temporal fossa, infratemporal fossa and zygomatic arch, intermediately and the occipital region posteriorly.[47] The zygomatic process forms the upper lateral rim of the orbit laterally and fuses with the frontal process of the zygomatic bone.[46,48] The zygomatic bone forms the lower lateral rim as well as the lateral part of the inferior rim of the orbit.[46] The zygomatic process of the maxilla articulates laterally with the zygomatic bone and the frontal process of each maxilla articulates medially with the frontal bone.[46]

An anterior bony prominence, called the zygomatic process, projects from the lower part of the squamous part of the temporal bone in a lateral direction that later turns anteriorly to articulate with the temporal process of the zygomatic bone as well as the zygomatic process of the frontal bone to form the zygomatic arch.[46,47,48] The infraorbital foramen is situated anteriorly on the body of the maxilla just below the inferior rim of the orbit.[46] The lateral view of the skull consists of the lateral part of the cranium and the face as well as half of the lower jaw.[46,48] The lateral part of the cranium is formed by the frontal, parietal, occipital, sphenoid and temporal bones.[46] The visible

part of the face from a lateral view includes the nasal, maxillary and zygomatic bones.[46] The visible part of the lower jaw is formed by the mandible.[46]

The lateral part of the cranium begins anteriorly with the frontal bone that articulates with the parietal bone superiorly at the coronal suture.[46] Posteriorly the parietal bone articulates with the occipital bone at the lambdoid suture.[46] The lower region of the lateral aspect of the calvarium is formed by the frontal bone articulating with the greater wing of the sphenoid bone.[46] The latter then articulates with the parietal bone at the sphenoparietal suture[46] and with the anterior edge of the squamous part of the temporal bone at the sphenosquamous suture.[46, 48] The squamosal suture separates the parietal and temporal bones from each other.[47]

The pterion is an H-shaped junction between sutures (sphenoparietal, sphenosquamous, coronal) and a weak point in the skull formed by the junction of the frontal, parietal, sphenoidal and temporal bones.[46,47,48] The pterion is clinically important because it overlies the middle meningeal artery as well as the lateral cerebral fissure.[47] The final articulation on the lower part of the lateral portion of the calvarium is at the occipitomastoid suture where the temporal and occipital bones articulate.[46]

The temporal bone is a major contributor to the lower part of the lateral cranium and it consists of four parts.[46] The squamous part forms the anterior and superior parts of the temporal bone and resembles a flat plate. The temporal bone forms part of the lateral wall and articulates with the greater wing of the sphenoid anteriorly and with the parietal bone superiorly.[46] Below the origin of the zygomatic process is the tympanic process containing the clearly visible external acoustic opening that leads to the

external acoustic meatus.[46,48] The final part is the petromastoid, which is separated into a petrous and mastoid part.[46] The most posterior part of the temporal bone is the mastoid process and is also the only part of the petromastoid portion of the temporal bone visible from a lateral view.[46]

The styloid process is often described as a sharp cone or spine like protrusion that is visible medially to the mastoid process. Bones of the viscerocranium visible laterally includes the nasal, maxilla and zygomatic bones as well as one of the paired nasal bones, the upper jaw formed by the alveolar process and teeth of the maxilla.[46] The maxilla forms the middle part of the lateral face and contributes to the inferior and medial borders of the orbit superiorly.[46] Medially, the frontal process of the maxilla articulates with the frontal bone and laterally the zygomatic process articulates with the zygomatic bone.[46] The zygomatic bone is an irregularly shaped bone forming the prominence of the cheek with its rounded lateral surface.[46] The zygomatic bones form the centrepiece of the lateral view and assists in the formation of the inferior orbit where it articulates with the zygomatic process of the maxilla.[46]

On the lateral surface of the zygomatic bone the small zygomaticofacial foramen can be found.[46] The mandible is the final bony structure visible from the lateral view.[46] Inferiorly and anteriorly the anterior body, posterior ramus and the angle (the point where the inferior border of the body meets the posterior border of the ramus) of the mandible can be seen.[46] The alveolar part containing the teeth, as well as the mental protuberance, can also be seen in this view.[46] The mental foramen is also found on the lateral surface as well as the condylar and the coronoid processes upward from the ramus.[46] The condylar process is involved in articulation of the temporal bone with the

mandible at the temporomandibular joint and the coronoid process serves as attachment for the temporalis muscle.[46]

3.3.1 Arterial supply of the face

The major blood vessel supplying the face is the facial artery, a branch from the anterior part of the external carotid artery that passes through the deep structures of the neck.[46] After passing posterior to the submandibular gland it appears again at the lower border of the mandible.[46] It curves around the inferior border of the mandible just anterior to the masseter, and it is at this point that it enters the face.[46] The artery runs upward and medially in a curved course, and passes along the side of the nose to terminate as the angular artery at the medial corner of the eye.[46] Along its course the artery lies deep to various muscles including platysma, risorius and zygomaticus major and minor. It lies superficial to the buccinator, as well as levator anguli oris, and in some instances pass superficially to or even through levator labii superioris.[46]

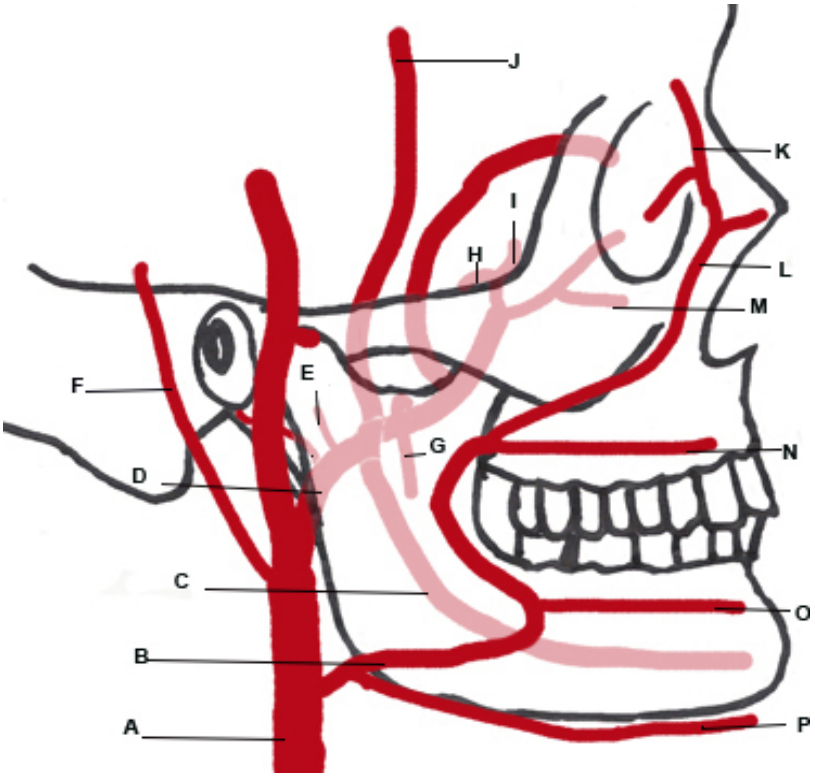
Two branches of the facial artery need to be noted, namely, the superior and inferior labial arteries that supply the upper and lower lip respectively.[46] The superior and inferior labial branches anastomose with the corresponding contralateral arteries near the midline.[46] This anastomosis provides an indirect connection between blood flow on both sides of the face.[46] The transverse facial artery is a branch of the superficial temporal artery, the smaller of the terminal branches of the external carotid artery.[46] This artery arises in the substance of the parotid gland and passes through the gland crossing the face in a transverse direction.[46] It lies on the surface of the masseter muscle and is found between the zygomatic arch and the parotid duct.[46]

Of the terminal branches of the external carotid artery, the maxillary is the largest and supplies the face by giving of several smaller branches.[46] The maxillary artery is of special interest when investigating the pterygopalatine fossa. The artery enters the pterygopalatine fossa through the pterygomaxillary fissure in an anterior, medial and superior direction.[49] It gives off several branches before exiting through the sphenopalatine foramen.[49] The maxillary artery divides into three parts after it arises posterior to the neck of the mandible.[49] These parts are named according to their location and include the mandibular, pterygoid and pterygopalatine parts.[49] The infraorbital artery arises from the maxillary artery and enters the face via the infraorbital foramen to supply the lower eyelid, upper lip, as well as the area between the two structures.[46]

Another branch of the maxillary is the buccal artery that enters the face anterior to the buccinator muscle and therefore supplies blood to the structures in this area[46]. The mental artery, the last branch of the maxillary artery, supplies the chin after exiting through the mental foramen.[46] The two arteries from the internal carotid that supply the face are branches of the ophthalmic artery.[46] The zygomaticofacial artery arises from the lacrimal branch of the ophthalmic artery and exits through the zygomaticofacial foramen.[46] It supplies the area of the face related to the zygomatic bone.[46] The last artery, a terminal branch of the ophthalmic, is the dorsal nasal artery that supplies the dorsum of the nose.[46] The supraorbital and supratrochlear branches of the ophthalmic artery supply the anterior scalp[46] (see Figure 3.1).

3.3.2 Venous drainage of the face

The major vessel draining the face is the facial vein with its point of origin near the corner of the orbit medially where the supratrochlear and supraorbital veins join to form the angular vein.[46] As the angular vein proceeds inferiorly to assume a position posterior to the facial artery it changes to the facial vein.[46] The facial vein and artery follow a similar path descending across the face down to the inferior border of the mandible. The artery and vein part at this point and the facial vein follows its own course passing superficially to the submandibular gland and entering the internal jugular vein.[46] Tributaries from veins draining the eyelids, external nose, lips, cheek and chin, all connect with the facial vein throughout its course and are all accompanied by branches from the facial artery.[46] The transverse facial vein, a small vein that accompanies the transverse facial artery, empties into the superficial temporal vein in the parotid gland substance.[46] The facial vein has numerous connections with venous channels passing into deeper regions of the head.[46] It communicates with ophthalmic veins near the corner of the orbit[46]. In the cheek area it communicates with veins passing into the infraorbital foramen.[46] It also communicates with veins passing into deeper regions of the face such as the pterygoid plexus. All these veins have interconnections through emissary veins with the cavernous sinus.[46] All of the veins mentioned above do not contain valves and therefore blood is able to move in any direction[46] (see Figure 3.2).



A. External carotid

B. Facial

C. Inferior alveolar

D. Maxillary

E. Middle meningeal

F. Posterior auricular

G. Masseteric

H. Descending palatine

I. Sphenopalatine

J. Deep temporal

K. Supratrochlear

L. Angular

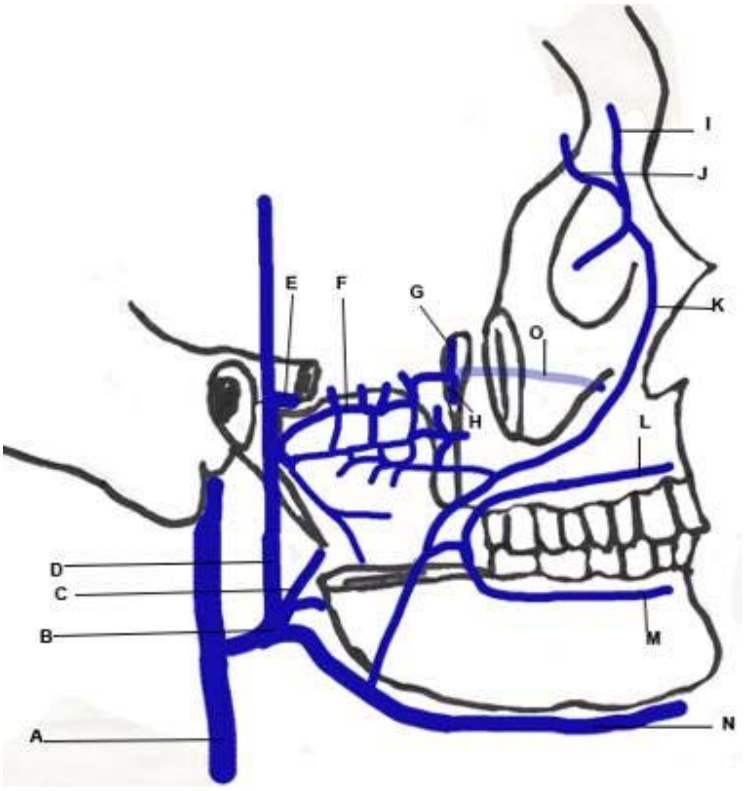
M. Superior alveolar

N. Superior labial

O. Inferior labial

P. Mental

Figure 3.1 *A schematic representation of the lateral view of the skull showing the branches of the external carotid artery with particular emphasis on the facial and maxillary branches. The pink coloured lines indicate vessels that are deep to the bony structures in the diagram.*[50,51,52]



A. Internal jugular
B. Common venous trunk
C. Lingual
D. Retromandibular
E. Transverse facial
F. Pterygoid plexus
G. Emissary vein
H. Palatine
I. Supratrochlear
J. Supraorbital
K. Angular
L. Superior labial
M. Inferior labial
N. Submental
O. Infraorbital

Figure 3.2 *A schematic representation of a right lateral view of the skull showing venous drainage of the face (zygomatic arch and ramus of the mandible removed).*[50,51,52]

3.3.3 Innervation of the face

There are two nerves that supplies sensory and motor innervation to the face. They are cranial nerves V (trigeminal nerve) and VII (facial nerve).[46] These will be discussed separately.

3.3.3.1 Trigeminal nerve

This is the largest cranial nerve. Sensory input to the face, anterior half of the scalp, mucous membranes of the oral, nasal and paranasal sinus cavities, part of the tympanic membrane, the eye, conjunctiva, as well as the dura mater in the anterior and

middle cranial fossa are all passed through the trigeminal nerve.[46] The motor innervation to the muscles of mastication, the tensor tympani, tensor veli palatini, mylohyoid, and the anterior belly of digastric comes from this nerve.[46] The trigeminal nerve can be divided into supra- and infranuclear parts. The latter is further divided into five segments, i.e. brainstem, cistern, Meckel's cave, cavernous sinus and extracranial.[35] It has four nuclei in the brain: mesencephalic for proprioception, a main sensory, motor and a spinal nucleus.[35] The trigeminal nuclei are predominantly located in the tegmentum of the lateral pons and lies along the ventrolateral aspect of the fourth ventricle.[35]

The trigeminal nerve exits as a large sensory root and small motor root on the anterolateral surface of the pons.[46] The roots continue forward out of the posterior cranial fossa and into the middle cranial fossa, by passing through the porus trigeminus of the dura.[35,46] The dural covering continues with the nerve as it passes over the medial tip of the petrous part of the temporal bone[35,46] and is followed by the leptomeninges causing a cerebrospinal fluid-filled space known as the trigeminal cistern.[35] Here the nerve enters a dural cave known as the trigeminal cave or Meckel's cave and it is at this point that the sensory root expands to form the trigeminal ganglion.[35,46] The ganglion contains the bodies for the sensory neurons in the trigeminal nerve and resembles a spinal ganglion.[46] The ganglion is located in Meckel's cave and is sometimes referred to as Meckel's ganglion.[35,46] At this point the motor root is completely separated from the sensory root.[46] Three divisions arise from the anterior border of the trigeminal ganglion. These are the terminal divisions of the nerve and are

the ophthalmic division (V_1), the maxillary division (V_2) and the mandibular division (V_3).[35, 46]

The first division, or ophthalmic nerve passes anteriorly in the dura mater of the lateral wall of the cavernous sinus. It then exits the cranial cavity and enters the orbit via the superior orbital fissure.[46] The ophthalmic nerve carries sensory branches from the eyes, conjunctiva and orbital contents as well as the lacrimal gland. Sensory branches from the nasal cavity, frontal and ethmoidal sinuses, upper eyelid, and dorsum of the nose as well as the anterior part of the scalp all connect with the ophthalmic nerve.[46]

Branches of the ophthalmic nerve:

a) Supra-orbital and supratrochlear nerves - exit the orbit superiorly and innervate the upper eyelid, forehead and scalp.[46]
b) Infratrochlear nerve - exits the orbit at the medial angle to innervate the medial half of the upper eyelid, the skin in the area of the medial angle and the side of the nose.[46]
c) Lacrimal nerve - exits the orbit at the lateral angle to innervate the lateral half of the upper eyelid as well as the skin in the area of the lateral angle.[46]
d) External nasal nerve - supply the anterior part of the nose.[46]

The second division, or maxillary nerve, passes forward in the dura mater of the lateral wall of the cavernous sinus accompanying the first division just superior to it.[46] The maxillary nerve exits the cranial cavity through the foramen rotundum from where it enters the pterygopalatine fossa.[46] Sensory branches from the dura mater in the middle

and anterior cranial fossae, the nasopharynx, palate, nasal cavity, teeth of the upper jaw, maxillary sinus, lower and upper eyelids, cheek and skin covering the side of the nose are all received by the maxillary nerve.[46]

Branches of the maxillary nerve:

a) Zygomaticotemporal - exits the zygomatic bone and supplies the small area of the anterior temple above the zygomatic arch.[46]
b) Zygomaticofacial - exits the zygomatic bone via the zygomaticofacial foramen and supplies a small area of skin over the zygomatic bone.[46]
c) Infraorbital - exits the maxilla through the infraorbital foramen and immediately divides into several branches to innervate lower eyelid, cheek, side of the nose, and upper lip as well as the teeth via its anterior and middle superior alveolar branches.[46]

The third division, or mandibular nerve, leaves the inferior margin of the trigeminal ganglion and exits the cranial cavity through the foramen ovale.[46] The motor root also passes through foramen ovale and connects with the sensory root outside the skull.[46] This is the only division of the trigeminal nerve which carries motor fibres.[46] Sensory fibres of the mandibular nerve include branches from the skin of the lower face, cheek, lower lip, ear, external acoustic meatus, and temporal region, anterior two thirds of the tongue, the teeth of the lower jaw, mastoid air cells, mucous membrane of the cheek, mandible as well as the dura mater in the middle cranial fossa.[46]

Branches of the mandibular nerve:

a) Auriculotemporal – enters the face just posterior to the temporomandibular

joint and then passes through the parotid gland ascending anterior to the ear to supply the external acoustic meatus, the surface of the tympanic membrane and a large part of the temporal area.[46]

b) Buccal nerve – lies on the surface of the buccinator muscle and supplies the cheek.[46]

c) Inferior alveolar nerve – enters the mandibular foramen and supplies the lower teeth and surrounding gingivae, mucosa and skin of the lower lip as well as the skin of the chin after it passes through the mental foramen to terminate as the mental nerve.[46]

3.3.3.2 Facial nerve

It exits the brainstem anterolaterally at the pontomedullary junction.[46] It consists of a large motor root and a small sensory root known as the intermediate nerve.[46] The motor and sensory roots cross the posterior cranial fossa and leave the cranial cavity via the internal acoustic meatus.[46] After entering the facial canal in the petrous part of the temporal bone, the two roots fuse to form the facial nerve. Near to this point, the nerve enlarges to form the geniculate ganglion.[46] The geniculate ganglion contains the cell bodies of the sensory neurons and resembles a spinal ganglion.[46] The greater petrosal nerve branches off at the geniculate ganglion, while the facial nerve continues along the bony canal giving rise to the nerve to stapedius and chorda tympani after which it exits the skull via the stylomastoid foramen.[46] The chorda tympani carries taste sensations from the anterior two-thirds of the tongue as well as some fibres destined for the submandibular ganglion.[46] There are five main branches of the facial nerve which

supplies the muscles of facial expression, all except (d) in the list below, exit as various branches that interconnect. They are as follows:

a) Temporal branches - these exit from the superior border of the parotid gland to supply muscles in the temporal area, forehead, and supraorbital area.[46]
b) Zygomatic branches - emerge from the anterosuperior border of the parotid gland and supply the muscles in the infraorbital, lateral nasal and upper lip area.[46]
c) Buccal branches - emerge from the anterior border of the parotid gland and supply muscles of the cheek, upper lip and corner of the mouth.[46]
d) Marginal mandibular branch - appear from the anteroinferior border of the parotid gland to supply the muscles of the lower lip and chin.[46]
e) Cervical branches - emerge from the inferior border of the parotid gland to supply platysma.[46]

3.3.4 Fossae located on the lateral aspect of the facial skeleton

There are three fossae on the lateral aspect of the skull, the temporal, infratemporal and pterygopalatine fossae. These will be described below.

3.3.4.1 The temporal fossa

This is the most superior fossa of the three and is found superior to the zygomatic arch. It interconnects with the infratemporal fossa through a gap between the zygomatic arch and the more medial surface of the skull.[46] The temporal fossa is a narrow fan shaped space covering the lateral surface of the skull.[46] The upper margin is

defined by two temporal lines arching across the skull from the zygomatic process of the frontal bone to the supramastoid crest of the temporal bone.[46] It is limited laterally by the temporal fascia, which is a tough fan shaped aponeurosis overlying the temporal muscle and attached to the superior temporal line by its outer margin and by its inferior margin to the zygomatic arch.[46]

The anterior border is the posterior surface of the frontal process of the zygomatic bone and the posterior surface of the zygomatic process of the frontal bone and this limits and separates it from the orbit in front.[46] The inferior border is defined by the zygomatic arch laterally and by the infratemporal crest of the greater wing of the sphenoid medially.[46] Between the medial and lateral parts of the inferior border, the floor of the temporal fossa is open to the infratemporal fossa medially and to the region containing the masseter muscle laterally.[46] The temporalis muscle forms the major content of the fossa, but it also contains the zygomaticotemporal branches of the maxillary nerve which enters the region through foramina on the surface of the zygomatic bone.[46]

3.3.4.2 The infratemporal fossa

This is a wedge shaped space that lies inferior to the temporal fossa, deep to masseter with the ramus of the mandible lateral and the wall of the pharynx medial.[46] It is open to the neck posterioinferiorly.[46] The roof of the infratemporal fossa is formed by the inferior surfaces of the greater wing of the sphenoidal and the temporal bones. It contains the foramen spinosum, foramen ovale and the petrotympanic fissure.[46] The roof of the infratemporal fossa is open to the temporal fossa lateral to the infratemporal

crest of the greater wing of the sphenoid. The medial surface of the ramus of the mandible containing the opening to the mandibular canal forms the lateral wall.[46]

Anteriorly, the medial wall is formed by the lateral plate of the pterygoid process and posteriorly the wall is formed by the two muscles of the soft palate. It contains the pterygomaxillary fissure anteriorly, which allows passage between the infratemporal and pterygopalatine fossae.[46] The anterior wall is formed by part of the posterior surface of the maxilla. It contains the alveolar foramen and its upper portion opens into the infraorbital fissure of the orbit.[46] All structures that pass through it are structures that travel between the cranial cavity, neck, pterygopalatine fossa, floor of the oral cavity, floor of the orbit and superficial regions of the head.[46] The major contents of the infratemporal fossa are: the sphenomandibular ligament, medial and lateral pterygoid muscles, maxillary artery, mandibular nerve, branches of the facial nerve, glossopharyngeal nerve and the pterygoid plexus of veins.[46]

3.3.4.3 Pterygopalatine fossa

The pterygopalatine fossa is a small pyramidal-shaped space situated on the lateral aspect of the skull immediately posterior to the maxilla.[46-50,53-55] It is in close relation to the angle at the junction of the sphenomaxillary and pterygomaxillary fissures and beneath the apex of the orbit.[47,48,50] This small fossa communicates with a variety of important areas through various foramina and fissures.[46] These include the middle cranial fossa, infratemporal fossa, floor of the orbit, lateral wall of the nasal cavity, oropharynx and the roof of the oral cavity.[46,48,50,54,56] Anatomical literature does not

define the margins of the fossa very clearly, or tends to disagree on many aspects. It is therefore a difficult task to locate, as well as describe, its exact area and location.[53]

Superiorly, the fossa is bordered by a small part of the inferior surface of the body of the sphenoid and anteriorly by the superomedial part of the infratemporal portion of the maxilla.[47-50,53,55,56] Posteriorly, the fossa is bordered by the pterygoid process of the sphenoid, as well as the anterior surface of the greater wing of the sphenoid.[46-50,53,55,56] The medial border is formed by the lateral vertical plate of the palate and laterally the pterygomaxillary fissure.[46-50,53,55,56] The floor of the fossa is formed by the pyramidal process of the palatine bone.[48] Opening into the posterior wall of the pterygopalatine fossa is the foramen rotundum (above), pterygoid canal (below and internal) and the palatovaginal canal (most inferior and internal).[46-48,50] The sphenopalatine foramen in the medial wall connects it with the lateral wall of the nasal cavity and the palatine canal opens inferiorly leading to the roof of the oral cavity.[46,50,55,56]

Occasionally, accessory orifices of two or three posterior palatine canals are also found.[50,56] The large pterygomaxillary fissure, located between the posterior surface of the maxilla and the pterygoid process of the sphenoid connects the lateral aspect of the pterygopalatine fossa with the infratemporal fossa.[46,47,50] The fossa contains the maxillary nerve, pterygopalatine ganglion, terminal part of the maxillary artery as well as fat.[46-48,53,54] The location and neurological contents of the pterygopalatine fossa is best described using a diagram (see figures 3.3 and 3.4).

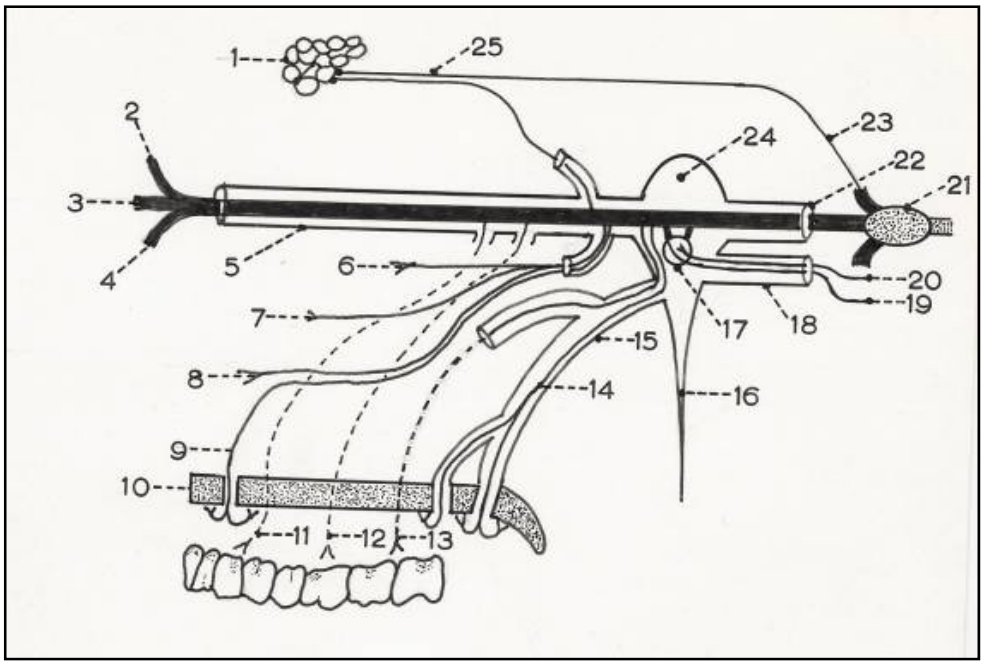


Figure 3.3 *A schematic representation of the major neurological structures passing through the pterygopalatine fossa. 1 Lacrimal gland, 2 Nasal branch, 3 Infraorbital Branch, 4 Superior labial branch, 5 Inferior orbital fissure, 6 Superior nasal branch, 7 Middle nasal branch, 8 Inferior nasal branch, 9 Nasopalatine branch, 10 Palate, 11 Anterior superior alveolar nerve, 12 Middle superior alveolar nerve, 13 Posterior superior alveolar nerve, 14 Greater palatine nerve, 15 Palatine canal, 16 Pterygomaxillary fissure, 17 Pterygopalatine ganglion, 18 Pterygoid canal, 19 Sensory branch of facial nerve, 20 Greater petrosal nerve, 21 Trigeminal ganglion, 22 Foramen rotundum, 23 Zygomaticotemporal nerve, 24 Pterygopalaine fossa, 25 Lacrimal nerve. (Courtesy of Professor JC Allan)*

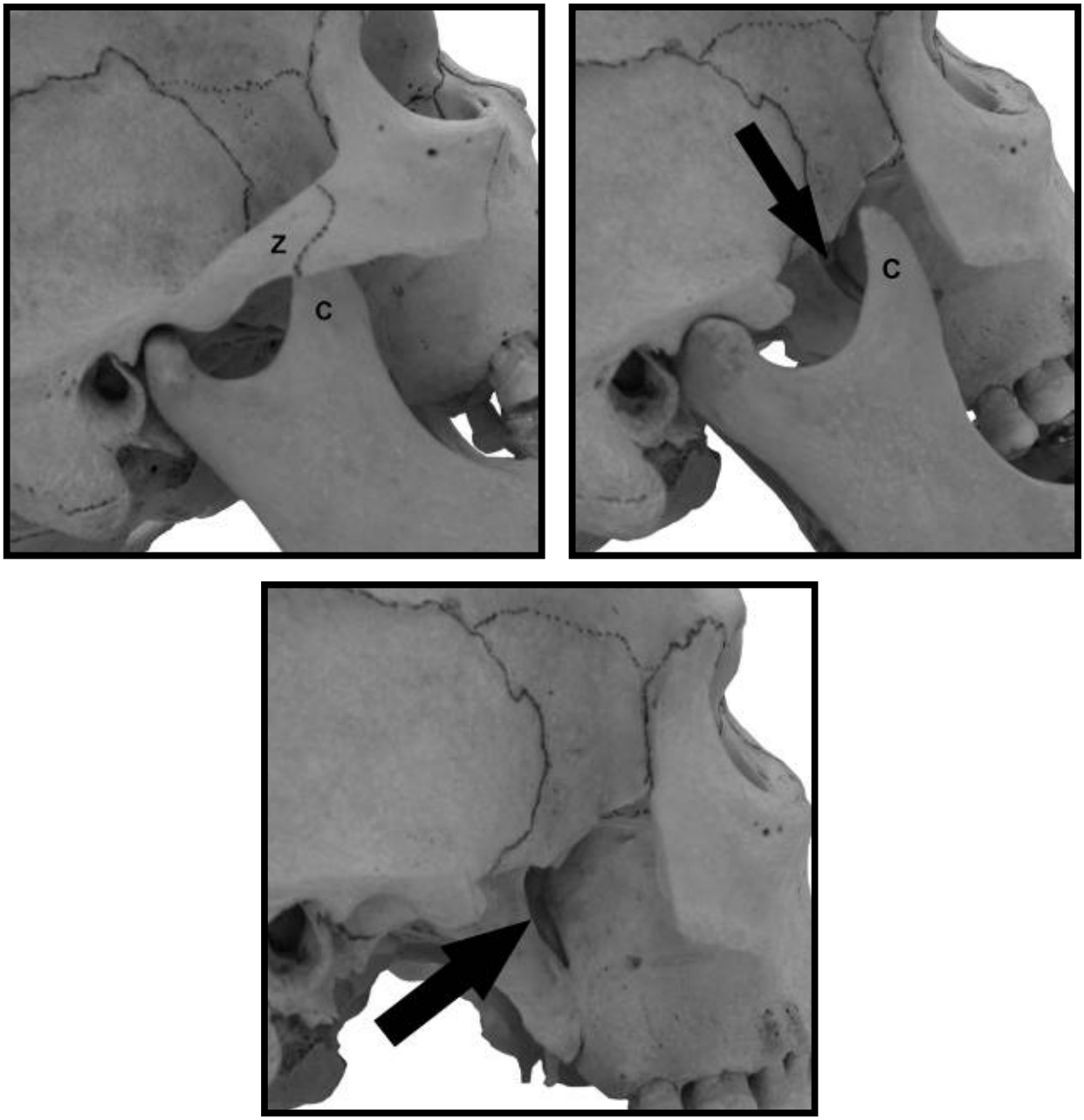


Figure 3.4 *A lateral view of the skull showing the pterygopalatine fossa and surrounding bony structures. (**A=** fossa obscured by the zygomatic arch (Z) and coronoid process (C) of the mandible, **B=** fossa slightly visible (zygomatic arch removed and mandible present), **C=** fossa clearly visible (zygomatic arch and mandible removed).*

4. Materials and methods

4.1 Materials

The study consisted of an osteological and a cadaveric part. A total of 160 adult human skulls were selected from the Pretoria Bone Collection for the initial part of this study. The skulls were selected with an equal distribution of sex and population affinity (40 white males, 40 white females, 40 black males, 40 black females). A digital calliper calibrated to the nearest millimeter (mm) was used to take all the anthropometric measurements. The calliper was set to zero before each skull was measured. The skulls were not placed in the Frankfort horizontal plane, which is the standard plane in which pictures and photographs are taken for comparison.[57] The Frankfort horizontal plane is accomplished by placing the skull in a head spanner or craniophore with two horizontal pieces in the left and right external ear openings and one on the left orbitale. As the porion is associated with the external ear opening, the equipment would have made some measurements difficult. It was felt that, because the morphology of the skulls was not compared to each other, it was not necessary to use this plane.

However, to facilitate measurement of the angle and depth, the skulls were placed in such a way that the zygomatic arch was orientated horizontally. Exclusion criteria for the skulls were based on the morphology of the lateral view of the face. No skull was selected if the zygomatic arch was broken or absent, or if the area was damaged in such a way as to obscure the visibility of the pterygopalatine fossa. If the lateral border of the orbit was damaged or broken in such a way that the landmarks were not clearly distinguishable, it was also excluded.

The second part of this study included dissection of 46 cadavers from the Anatomy department at the University of Pretoria and one cadaver from the University of the Witwatersrand. The cadavers from the University of Pretoria were all previously dissected by medical students. The cadaver from the University of the Witwatersrand was not previously dissected and was used to portray the methods as seen in Figures 4.5 to 4.11. A standard dissection kit including a scalpel with removable blades, scissors and forceps was used. All measurements taken on the cadavers were recorded in millimetres with a digital calliper. Calibrated 16-gauge catheter needles were used to test the formula generated by the skeletal study, by placing the needle in the cadaver at the point where the pterygopalatine fossa was predicted to be. The only exclusion criteria for the cadavers were if it fell into any other population affinity other than black or white. The exclusion criteria for the cadavers were determined after statistical analysis was done on the measurements taken from the skulls.

4.2 Methods

4.2.1 Craniometric Methods

The first aim was to determine the location of the pterygopalatine fossa by using measurements of related anatomical landmarks. Nine measurements were taken – five (namely, A, B, C, depth and angle) on the lateral side of the skull on both the left and right sides and the remaining four (namely, D, E, F, G) were taken in the midline of the face. Four of the landmarks used for measurements on the lateral surface of the skull are shown in Figure 4.1.

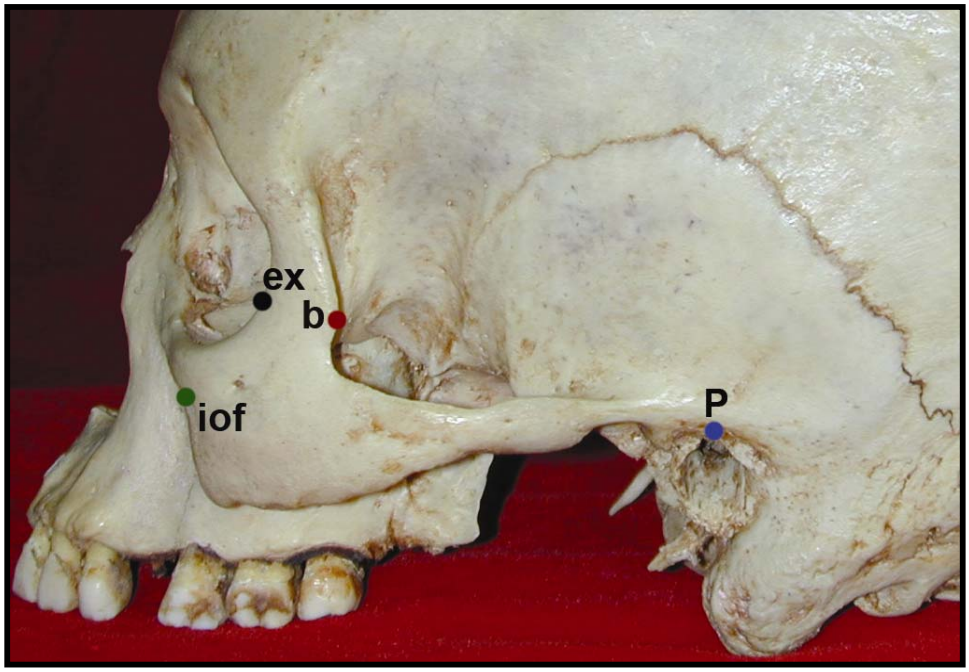


Figure 4.1 *Lateral view of the skull showing four bony landmarks, namely, exocanthion (ex), porion (P), infraorbital foramen (iof) and landmark b (b). These were used to determine the first three measurements of the skeletal part of the study.*

The osteological measurements were taken as follows:

Measurement A: The distance between the exocanthion (ex), which is a bony landmark that corresponds to the lateral corner of the eye, and the porion, which is the highest lateral point on the external acoustic meatus[43] (see Figure 4.2).

Measurement B: This was determined by using measurement A as a reference. It was measured from the exocanthion (ex) to a point on the posterior border of the frontal process of the zygomatic bone, referred to as landmark b. The measurement was taken in the same plane as measurement A (see Figure 4.2).

Measurement C: This was taken from the infraorbital foramen (iof) to landmark b on the posterior border of the frontal process of the zygomatic bone used in measurement B (see Figure 4.2).

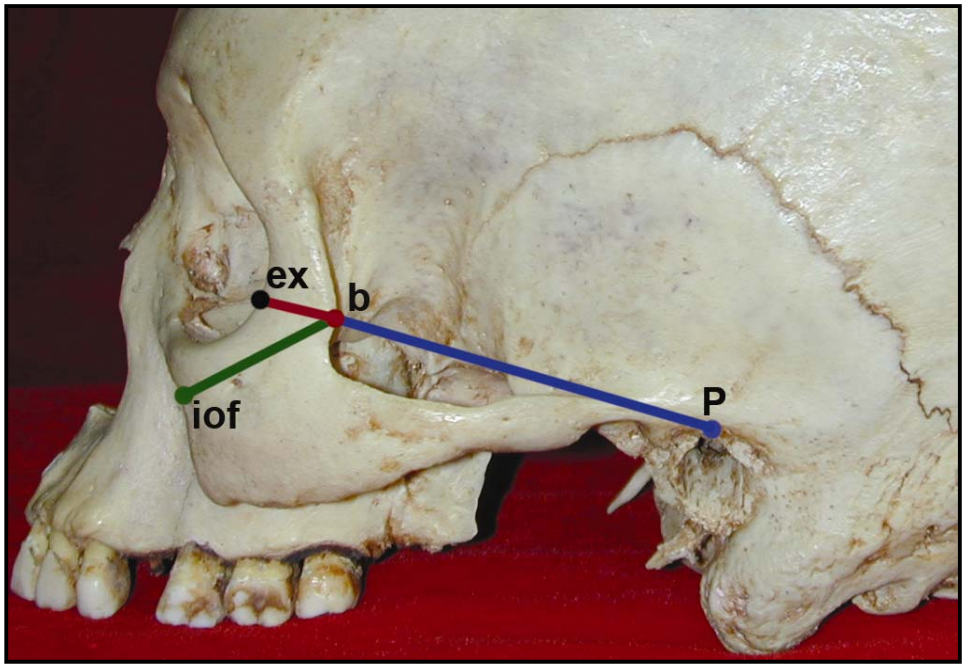


Figure 4.2 *Lateral view of the skull indicating measurement A (blue and red lines combined (ex-P)). Measurement B (red line (ex-b)) and measurement C (Green line (iof-b).*

Depth to the fossa from the zygomatic bone: This was measured by placing a calibrated lumbar puncture (LP) needle perpendicular to measurement A and then passing the needle in a medial direction towards the pterygopalatine fossa so that the tip of the needle touches the roof of the fossa. The depth (in millimetres) that the calibrated needle traverse from the line used in measurement A to reach the approximate midpoint of the roof of the pterygopalatine fossa was then measured.

Angle: For the determination of the angle at which the pterygopalatine fossa is located in relation to the zygomatic bone, a LP needle was placed at landmark b and then advanced, until the needle tip reaches the roof of the fossa. The angle at which the LP needle is directed was determined with the aid of a protractor. The angle was determined by placing the 90º point at the place where the needle crosses the

zygomatic bone and the base of the protractor on the zygomatic bone. The 90º point was therefore used as the 0º mark for the entrance point of the needle. The angle at which the tip of the needle was inserted into the fossa was calculated by reading the number of degrees that the end of the needle was located superiorly to the entrance point (see Figure 4.3).

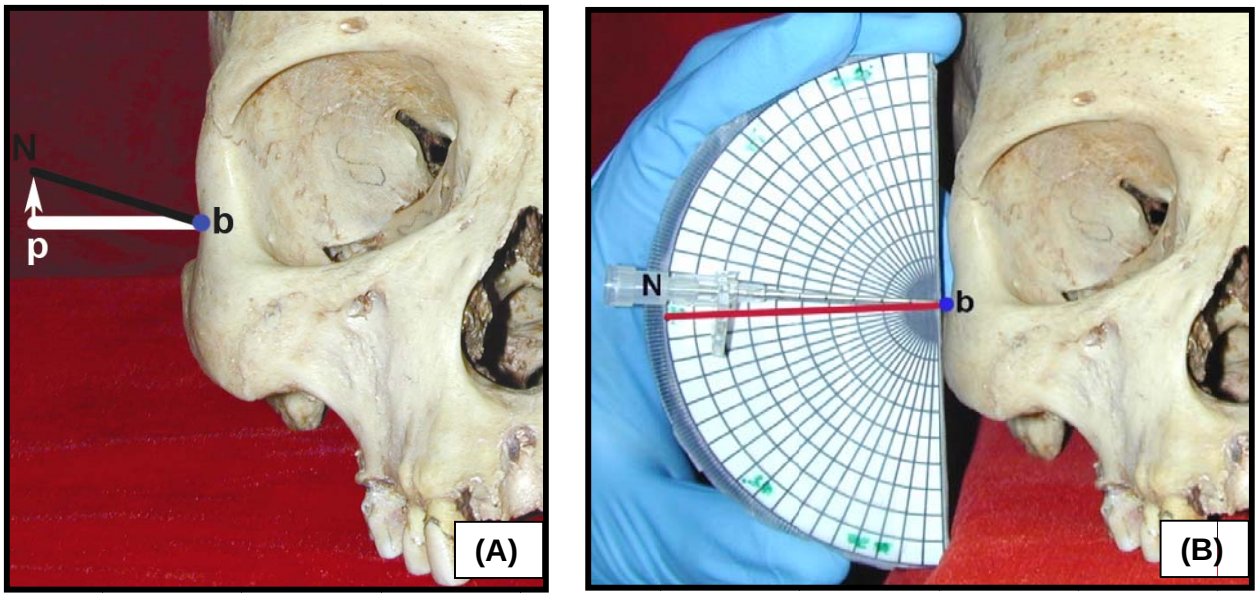


Figure 4.3 *Frontal view of the right half of a skull indicating how the angle and depth was determined. In A the horizontal white line indicates the plane used as 0º (the 90º line of the protractor) with landmark b indicated by the blue dot and the position of the needle indicated by the obliquely drawn black line. The arrow indicates the direction in which the angle was determined from the entry point of the needle. In B one can observe the placement of the protractor with the red line indicating 90 degrees. N indicates the needle; b indicates landmark b and P indicates the protractor.*

Measurement D: The distance between the infraorbital foramina. Figure 4.4 shows positioning of the tip of the calliper at the approximate midpoint of each infraorbital foramen.

Measurement E: This is the bizygomatic breadth, which is the distance between the most lateral points of the zygomatic arches[43], was measured (Figure 4.4).

Measurement F: This is the distance between the medial borders of the orbit known as the dacryon (dc-dc). For the purpose of this study, it will be referred to as the interorbital breadth[43] (Figure 4.4).

Measurement G: This is the least frontal breadth which is the shortest distance between the two most medial points of the temporal ridge (ft-ft) commonly referred to as the temple[43] (Figure 4.4).

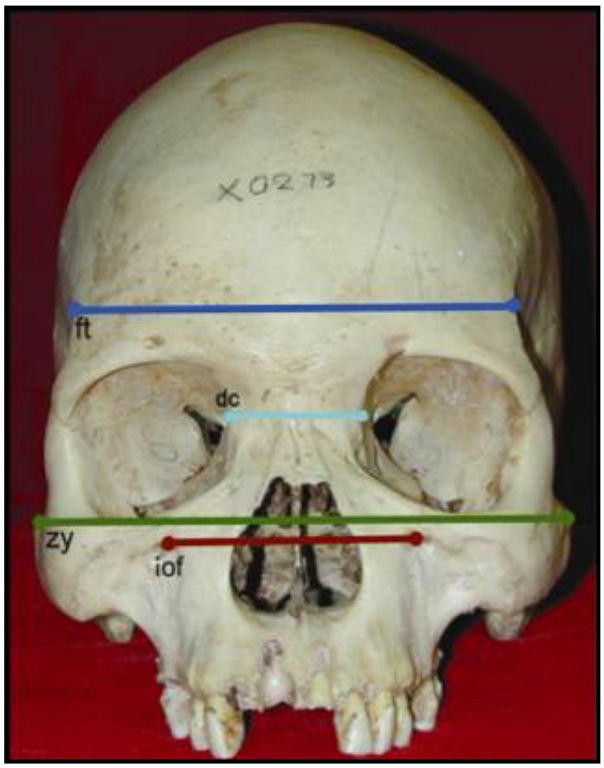


Figure 4.4 *A frontal view of the skull showing standard anthropological measurements: measurement E, (zy-zy) indicated by the green line. Measurement F, (dc-dc) indicated by the light blue line. Measurement G, (ft-ft) indicated by the dark blue line. As well as measurement D, (iof-iof) indicated by the red line that was developed for this study.*

4.2.1.1 Statistical analysis for craniometrical methods

The morphological features of the face display sexual dimorphism which distinguishes between males and females within and between different populations. For comparative purposes the results of this study were divided into eight groups. The groups compared were: females to males, blacks to whites, black females to white females and black males to white males.

The second aim was to use the data collected from the first aim to determine whether differences in the location of the pterygopalatine fossa exists between the various age, sex and population, as well as between the right and left sides of the face. The third aim was to devise a formula or formulae (depending on the results from the data collected) for estimating the location of the pterygopalatine fossa in any given individual by using demographic information together with measurable landmarks. These aims were accomplished by statistical analysis.

The measurements taken from the skulls were placed in a data sheet on which regression analysis was performed with Statistix V8.0. The aim of the regression analysis was to determine the association between the measurements, as well as demographic factors such as age, sex and population affinity obtained from the skulls. The data was split into two groups – one containing measurements on the right and one for those on the left. It was further divided into population and sex groups namely: white male, black male, white female, black female for comparative purposes.

Regression analysis provides information of the strength of influence that one variable has on another. In this study multiple regression analysis was used which tests

the influences of all of the factors on each other. This expresses how big the influence of change one variable will have on the predicted value, in the case of this study, the location of the pterygopalatine fossa. A p-value of less than 0.05 implies a true difference and is therefore significant at the five percent level. The mean values (mm), standard deviation (sd) and standard error (SE) was also determined as part of the regression analysis, as it is required in the t-test. The data from this statistical analysis provided two formulae that included the most significant factors for predicting the location of the pterygopalatine fossa in any individual regardless of sex or population. The formula generally used for multiple regression analysis is as follows:

$$\mathbf{Y = f\,(a, b, c) + constant}$$

Where Y is the predicted value, f is the coefficient of the variables, a, b and c indicate the dimensions of the different variables and the constant is a value calculated by the regression analysis.

To devise an index for each sex and race using the data collected from the previous two aims, the first two measurements for aim one was used and placed in an equation. The standard equation for all indices that were used is:

$$\mathbf{Y = \frac{B}{A} \times 100}$$

Where B is equal to measurement B (mm), A is equal to measurement A (mm), and Y is the percentage of the value for measurement A at which the pterygopalatine fossa would be found in relation to the exocanthion.

The indices were calculated for each specimen, as well as a combined index, using the mean values of each population and sex. An index for differences between the sides was calculated separately. These indices might be useful in combination with other existing indices to determine the population or sex of an unknown specimen.

4.2.2 Cadaveric Methods

The two formulae created from the study on the skulls were used to locate the pterygopalatine fossa in a sample of cadavers. As the pterygopalatine ganglion and maxillary nerve are closely related to the pterygomaxillary fissure, as well as to the entrance to the fossa, it was postulated that the formula could be used to block the nerve and ganglion.

In order to determine the accuracy of the formulae, it was tested on 47 cadavers. The data obtained from the anthropometric study was applied to the formula and it was found that measurement A and measurement C had a significant influence on measurement B and therefore the location of the fossa. Two formulae were created, one for each side of the face, the factors mentioned above were multiplied by a coefficient (calculated by regression analysis) and then added to the constant (calculated during the regression analysis). The formulae are as follows:

For the left:

Measurement B = 0.1040883 x A*left* + 1.267808 x race + 0.3675193 x C*left* + (-8.4207)

For the right:

Measurement B = 0.1014403 x A*right* + 1.201275 x race + 0.3616089 x C*right* + (-8.1076)

Where B indicates the location of the fossa from the exocanthion (measurement B), A indicates measurement A and C indicating measurement C. A denominator was used to indicate each population group.

The formulae were tested by taking measurement A, from exocanthion (ex) to the porion (P) and measurement C, from the infraorbital foramen to the landmark b on the posterior border of the frontal process of the zygomatic bone (see Figures 4.5 to 4.8). Measurements A and C were recorded on the cadavers. The values recorded in millimeters for measurements A and C were inserted into the formula together with the denominator for population group (0=white and 1=black) and the coefficient for left or right sides as calculated by the regression analysis. In this way measurement B, which was recorded from exocanthion (ex) to landmark b in the same plane as measurement A, was estimated. Landmark b was identified by the value obtained from the regression analysis. The needle was then inserted at the distance from the exocanthion to the lateral border of the zygomatic process that was determined by the formula, namely, measurement B (Figure 4.9). The angle and depth at which the needle should be inserted was determined by using the mean value (mm) of the specific group to which the individual belonged (e.g. black male) as obtained by the measurements on the skulls. Figure 4.10 shows how the angle was determined with the aid of a protractor.

For the previously dissected cadavers from Pretoria University, the dissections were carried out from an intraoral approach as the mandible was previously removed.

The cadaver from the University of the Witwatersrand was not previously dissected and had the mandible intact; therefore a lateral approach was used. The needles were placed on each side according to the procedure mentioned previously. After insertion of the needles, the area around each needle was then carefully dissected. Care was taken not to disturb or disrupt the needle's position. Dissection of the remaining soft tissue was performed in the region of the needle to locate its point (see Figure 4.11). Once identified, the relation of the needle to the pterygopalatine fossa was established. The presence of soft tissue on the face of the already dissected cadaver aided in locating the fossa as this simplified the correct insertion of the needle. In most cases, both the medial and lateral pterygoid muscles were removed to aid visibility of the pterygopalatine fossa. The presence of the nerves and blood vessels in and around the pterygopalatine fossa could not be investigated due to the cadavers having been dissected previously which in many instances, destroyed most of these structures.

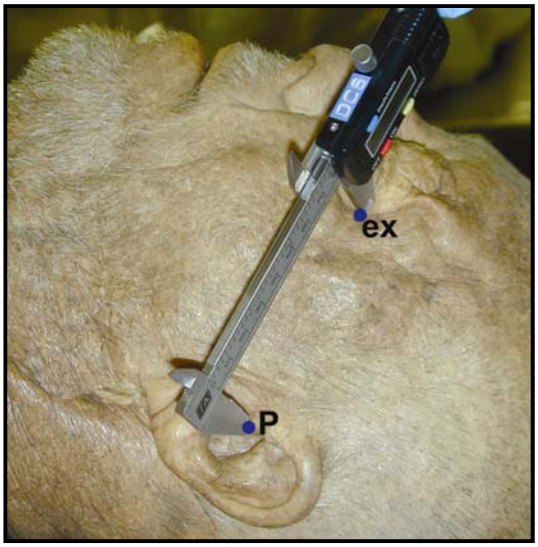


Figure 4.5 *A lateral view of the face showing the placement of the calliper on the cadaver for taking measurement A: exocanthion (ex) to porion (P). The bony landmark indicated by ex was palpated before placement of the calliper.*

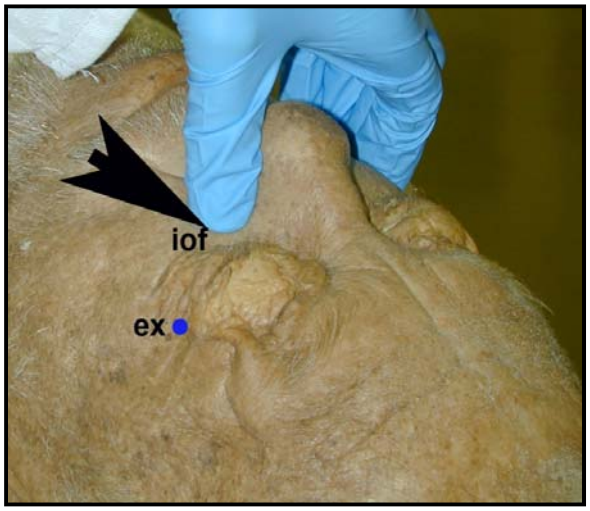


Figure 4.6 *Step one in determining the placement of the calliper for taking measurement C. The infraorbital foramen (iof) is palpated with the thumb by feeling for the indentation it causes close to the lower border of the orbit. The position of the infraorbital foramen in this individual is indicated by the arrow.*

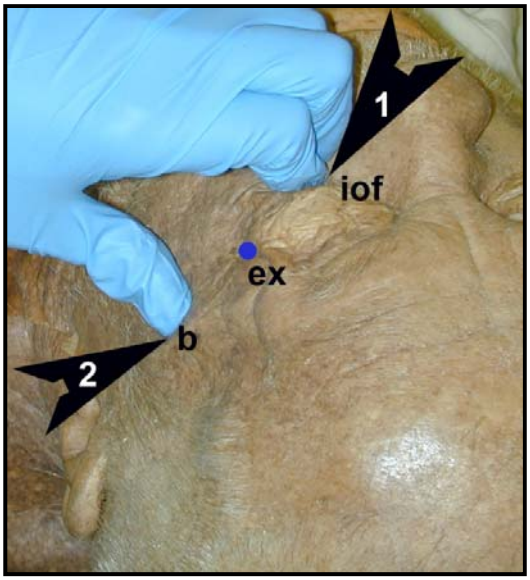


Figure 4.7 *Step two in determining the placement of the calliper for taking measurement C. The index finger is placed on the infraorbital foramen (iof) (indicated by arrow 1) while the posterior border of the zygomatic process is palpated (landmark b) indicated by arrow 2. Care was taken to align landmark b to the plane in which measurement A was taken. This was accomplished by noting the position of the exocanthion (ex) and the porion (P).*

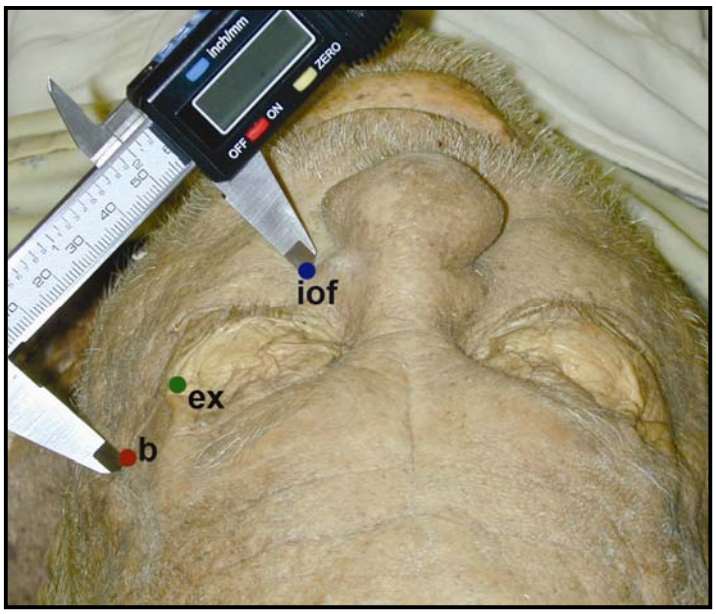


Figure 4.8 *The calliper is placed at the exact point where the palpation of both the infraorbital foramen and landmark b was performed.*

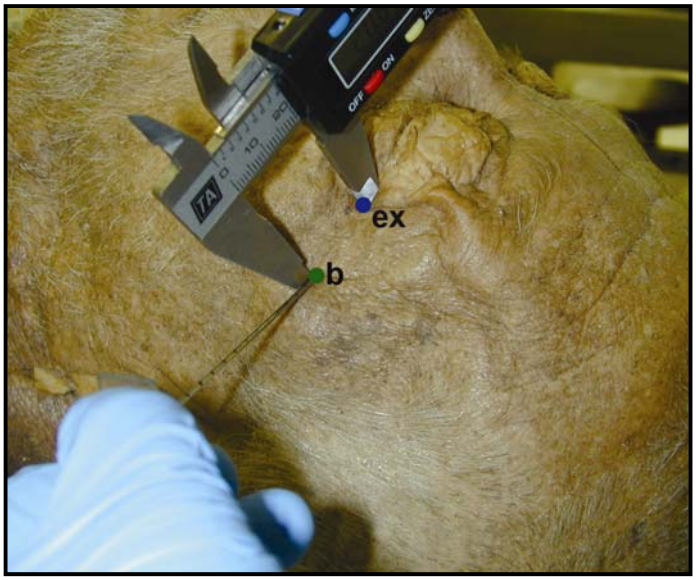


Figure 4.9 *Placement of the calliper at the calculated point of landmark b. The distance obtained by the formula is measured on the calliper and the calliper is locked. The one end of the calliper is then placed on the exocanthion (ex) and the other in the direction of the porion. The needle is then placed at the new landmark b as indicated by the calliper arm.*

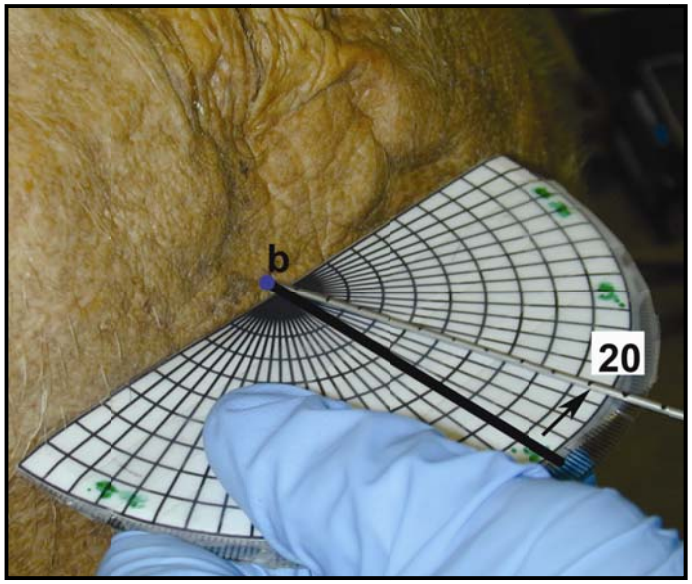


Figure 4.10 *Determination of the angle at which the needle should be advanced. The needle was placed and the protractor held so that the 90° line intersected the entry point of the needle. The needle was then adjusted to the angle required as calculated from the means of the different groups. The angle was adjusted in a superior direction as indicated by the arrow. In this case a deviation of approximately 20° was needed.*

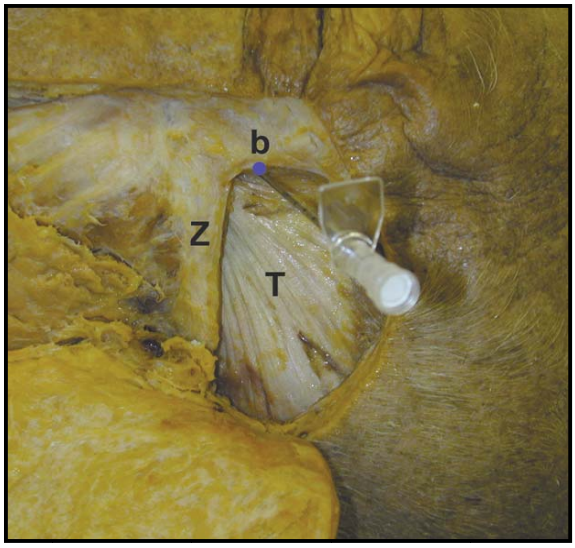


Figure 4.11 *Lateral view of the face with superficial soft tissue removed in order to expose the point of the needle; b indicates the entry point of the needle with the zygomatic arch (Z). The needle passed through the temporal (T) muscle in this instance.*

5. Results

5.1 Results from the anthropometric study

The mean values (mm) and standard deviations (sd) of the measurements taken on the skulls are shown in Tables 5.1 and 5.2. Graphs 5.1 and 5.2 is a comparison of the mean values (mm) and standard deviations (sd) of measurement A taken from the exocanthion (the bony landmark that corresponds to the lateral corner of the eye), to the porion (the highest lateral point on the external acoustic meatus[43]) between the different groups.

Graphs 5.3 and 5.4 compares the mean values (mm) and standard deviations (sd) of measurement B which was recorded from exocanthion to a point on the posterior border of the frontal process of the zygomatic bone (landmark b), between the different groups on the left and right respectively. Graphs 5.5 and 5.6 compares the mean values (mm) and standard deviations (sd) of the measured angle between the different groups for left and right respectively. Graphs 5.7 and 5.8 compares the mean values (mm) and standard deviations (sd) of the depth measured between the different groups for left and right respectively. Graphs 5.9 and 5.10 compares the mean values (mm) and standard deviations (sd) of measurement C (from the infraorbital foramen to landmark b on the posterior border of the frontal process of the zygomatic bone), between the different groups on the left and right respectively.

The bizygomatic breadth (mm) is illustrated in the graphs that follow and show the comparison between the different groups for each remaining measurement. The differences between the mean values (mm) and standard deviations (sd) of bizygomatic

breadth for the different groups are shown in graph 5.11. Graphs 5.12 and 5.13 depict the mean values (mm) and standard deviations (sd) for the distance between the left and right infraorbital foramen and biorbital breadth respectively. The least frontal breadth mean values (mm) and standard deviations (sd) in the different groups are shown in graph 5.14. The mean values (mm) and standard deviations (sd) for the index calculated are shown in graph 5.15. Table 5.3 and its accompanying graph 5.16 shows the intraclass correlation for measurements A and B, as well as the depth and angle that was measured for a second time, two weeks after the initial measurements was taken.

After using the regression analysis for measurements A, B and C as well as IFOB, BZB and IOB, it was discovered that measurement B can only be predicted with an accuracy of 45% on the left and 50,3% on the right. The factors that significantly influenced measurement B was race, measurement A and measurement C. Table 5.4 is a summary of the p-values obtained from the regression analysis that was done. When omitting the insignificant factors, the accuracy of predicting measurement B increases slightly on the left to 46,3 and on the right increases to 51,3%. Graphs 5.17 and 5.18 are the scatter graphs for the predicted values against the actual measured values for left and right respectively. It should be evident that the accuracy of estimation is slightly higher on the right than on the left. The regression analysis was done with the help of a statistician using Statistix version eight software. The formulae that was developed to estimate the point where the needle will be placed was determined from the analysis of the data by multivariate regression. We omitted any significant variations on the mean in order to predict measurement B as accurately as possible.

The following formulae were developed by using the general formula used in regression analysis:

Measurement B = f(measurement C, population, measurement A) + constant

Measurement B = (f_C x C) + (fp x population) + (f_A x A) + constant

Where measurement B indicates the position of the pterygopalatine fossa with regards to exocanthion, f indicates the coefficient of each variable as calculated with the regression analyses. The variables to be used are measurement A, population and measurement C. The constant is as calculated by the regression analyses.

Therefore the formulae developed to predict measurement B was as follows:

For the left side:

Measurement B = (0.1040883 x measurement A) + (1.267808 x population) + (0.3675193 x measurement C) + (-8 .4207)

For the right side:

Measurement B = (0.1014403 x measurement A) + (1.201275 x population) + (0.3616089 x measurement C) + (-8.1076)

Table 5.1 *Mean values (mm) and standard deviation (sd) of measurements taken on the skulls for females, males, blacks and whites.*

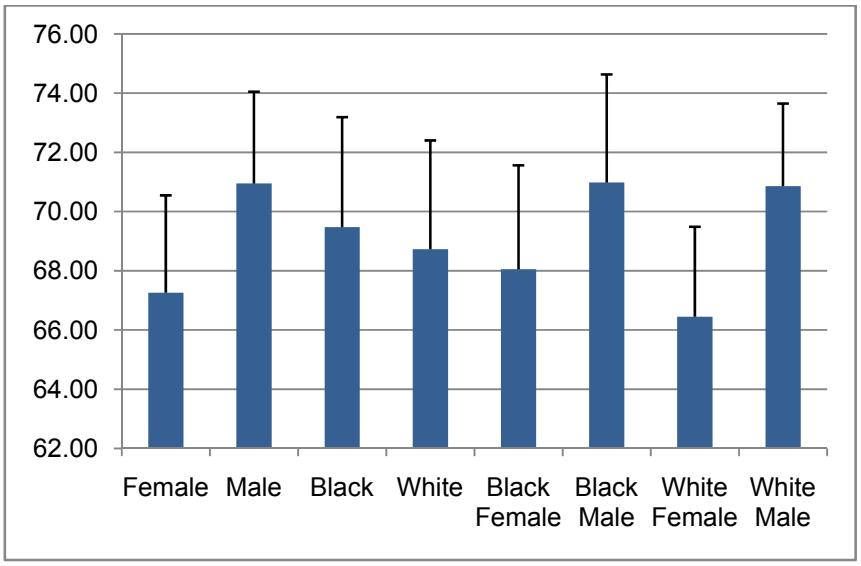
	Female		Male		Black		White	
Measuremen	**Mean**	**sd**	**Mean**	**sd**	**Mean**	**sd**	**Mean**	**sd**
A_Left	67.26	3.29	70.95	3.10	69.48	3.72	68.73	3.68
A_Right	68.07	3.60	71.43	3.23	70.63	4.03	68.87	3.40
B_Left	12.41	2.52	13.34	1.78	13.65	2.46	12.10	1.68
B_Right	12.24	1.93	13.46	1.74	13.54	1.97	12.15	1.66
Ang_L	20.41	4.56	19.15	4.56	20.00	4.96	19.56	4.28
Ang_R	20.61	4.31	19.05	3.97	19.00	4.02	20.64	4.30
Dep_L	44.25	4.32	46.97	3.69	45.71	3.63	45.51	4.82
Dep_R	44.14	3.34	46.43	4.24	45.65	4.34	44.94	3.63
C_L	35.76	2.53	37.22	2.16	36.49	2.44	36.48	2.52
C_R	35.69	2.90	37.68	2.21	36.58	2.75	36.78	2.81
BZB	123.53	4.88	131.78	5.16	127.90	6.55	127.36	6.53
BIOFB	52.01	4.60	55.45	5.09	56.41	4.57	51.05	4.28
IOB	20.75	2.77	21.41	2.76	22.72	2.45	19.44	2.06
LFB	95.17	3.63	98.09	3.74	97.49	3.89	95.77	3.89
Left Index	18.46	3.72	18.81	2.46	19.65	3.61	17.61	2.24
Right Index	17.97	2.67	18.84	2.26	19.17	2.57	17.65	2.23

Table 5.2 *Mean values (mm) and standard deviation (sd) of the anthropometrics done on the skulls for black females, black males, white females and white males.*

	Black Female		Black Male		White Female		White Male	
Measurement	**Mean**	**sd**	**Mean**	**sd**	**Mean**	**sd**	**Mean**	**sd**
A_Left	68.05	3.52	70.98	3.65	66.45	3.04	70.86	2.79
A_Right	69.13	3.93	72.00	3.81	66.87	2.84	70.79	2.81
B_Left	13.32	3.03	14.02	1.79	11.52	1.62	12.70	1.62
B_Right	12.89	2.09	14.21	1.71	11.56	1.59	12.80	1.57
Ang_L	20.49	5.05	19.73	4.84	20.03	4.10	18.78	4.34
Ang_R	19.24	4.19	19.06	3.79	22.03	4.05	19.50	4.22
Dep_L	44.34	3.60	46.96	3.31	44.11	5.22	46.95	4.20
Dep_R	44.97	3.64	46.66	5.01	43.39	3.03	46.53	3.64
C_L	35.71	2.57	37.29	2.12	35.74	2.66	37.16	2.25
C_R	35.58	2.91	37.49	2.38	35.64	3.01	38.02	2.15
BZB	123.74	5.22	132.20	5.30	123.29	4.56	131.57	5.31
BIOFB	54.49	3.80	58.08	4.38	49.34	3.63	52.77	4.37
IOB	22.36	2.32	23.09	2.63	19.10	2.24	19.77	1.92
LFB	95.66	3.44	99.06	3.65	94.57	3.73	96.89	3.85
Left Index	19.57	4.66	19.75	2.34	17.34	2.28	17.92	2.28
Right Index	18.65	3.05	19.73	2.01	17.29	2.21	18.08	2.26

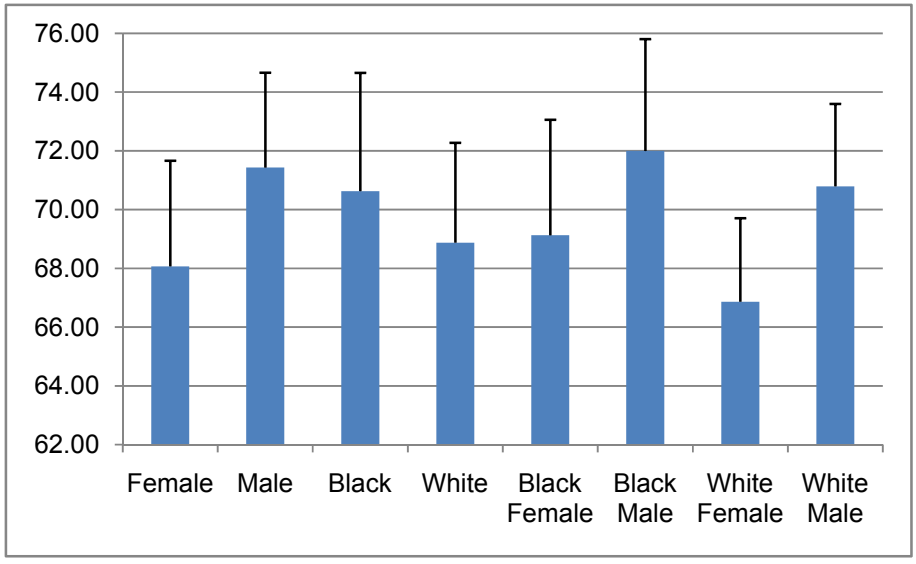
A graphic representation gives a better understanding of the impact of each of the values that is depicted in tables 5.1 and 5.2. The graphs that follow are therefore all based on the information given in these two tables.

The means (columns) and standard deviation (vertical lines) for measurement A: exocanthion – the bony landmark that corresponds to the lateral corner of the eye to the porion, the highest lateral point on the external acoustic meatus, on the left is depicted in graph 5.1. When comparing the black females to white females, the mean values (mm) are not statistically significant (p=0.738). However, when the black males were compared to the white males the mean values (mm) were significantly different (p=0.022). When comparing the mean values between males and females within the same population the p-value is equal to zero for both.



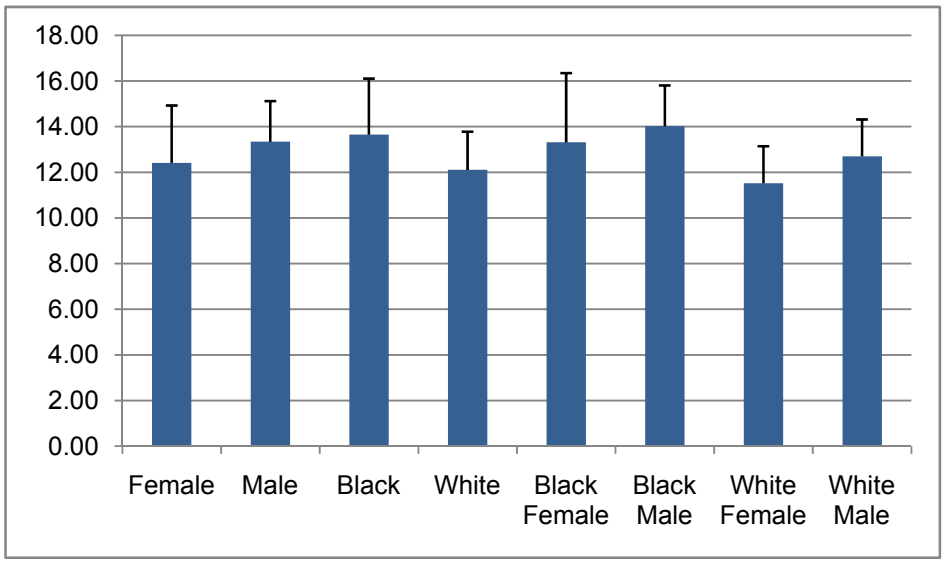
Graph 5.1 *The mean values (mm) and standard deviation (sd) for measurement A taken on the left.*

The means (columns) and standard deviation (vertical lines) for measurement A: exocanthion – the bony landmark that corresponds to the lateral corner of the eye to the porion, the highest lateral point on the external acoustic meatus on the right is shown in graph 5.2. It can be seen that the mean values for males were larger than for females and was statistically different when comparing within populations. The p-value for black male and female is statistically significant (p=0.003). Similarly when comparing white males and females, the difference is also significant (p=0). When comparing males of different populations it is found to be significant (p=0.002). However when comparing females from different populations the difference is not significant (p=0.18). When comparing graphs 5.1 and 5.2 it seems that there is a clearly distinguishable difference between the values for left and right with regards to measurement A. The values on the right are much larger than those on the left. However, the difference between left and right was not significant as an unpaired t-test yielded (p=0.735).



Graph 5.2 *The mean values (mm) and standard deviation (sd) for measurement A on the right.*

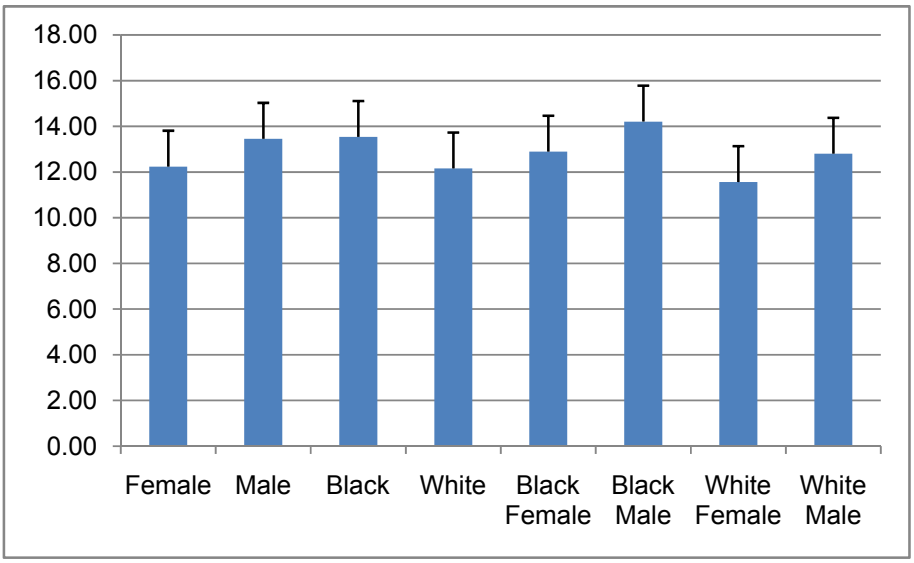
The means (columns) and standard deviation (vertical lines) for measurement B (exocanthion to landmark b) on the left can be seen in graph 5.3. In this instance, the differences between the groups were much smaller than those for measurement A. However, males did show slightly larger values when compared to females and blacks compared to whites. There was no significant difference in the mean values obtained for differences between black males and females (p=0.254). If one compares the other groups in the same manner as above it can be seen that the means are significantly different for all groups (range p=0 to 0.002).



Graph 5.3 *The mean values (mm) and standard deviation (sd) for measurement B on the left.*

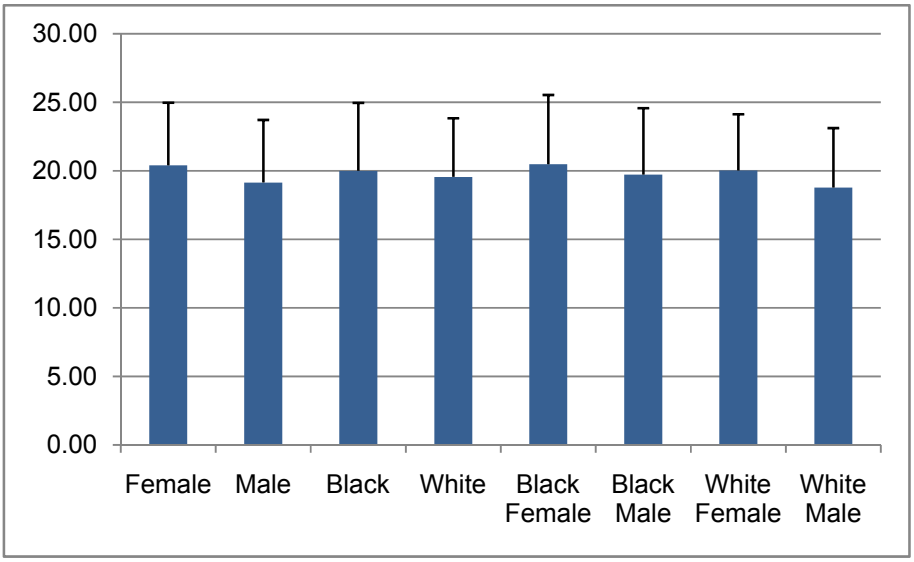
The means (columns) and standard deviation (vertical lines) for measurement B: exocanthion to landmark b on the posterior aspect of the zygomatic process on the right is demonstrated by graph 5.4. When comparing the different groups it can be seen that there is a significant difference between all the groups (range p=0.001 to 0.003). The

graph for measurement B on the left show similar differences between the groups and is not significantly different.

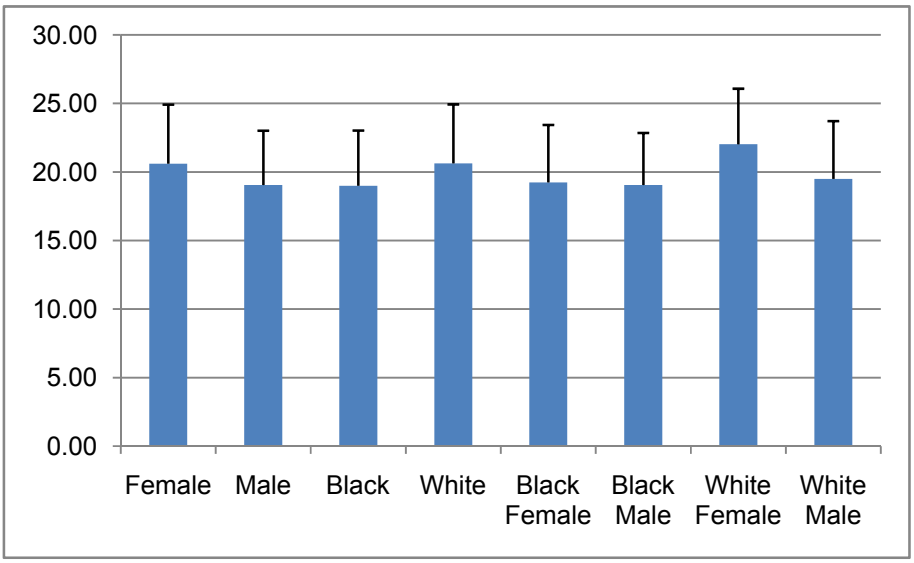


Graph 5.4 *The mean values (mm) and standard deviation (sd) for measurement B on the right.*

The means (columns) and standard deviation (vertical lines) for the angle at which the needle entered the pterygopalatine fossa on the left is shown in graph 5.5 and for the right is shown in graph 5.6. There is variation between the groups on the left, but this difference is minimal. The variation between the groups appears to be larger on the right than for the left side. There is a marked difference between the values for the left and the right. A t-test confirmed the differences between left and right to be significant (p=0.004).



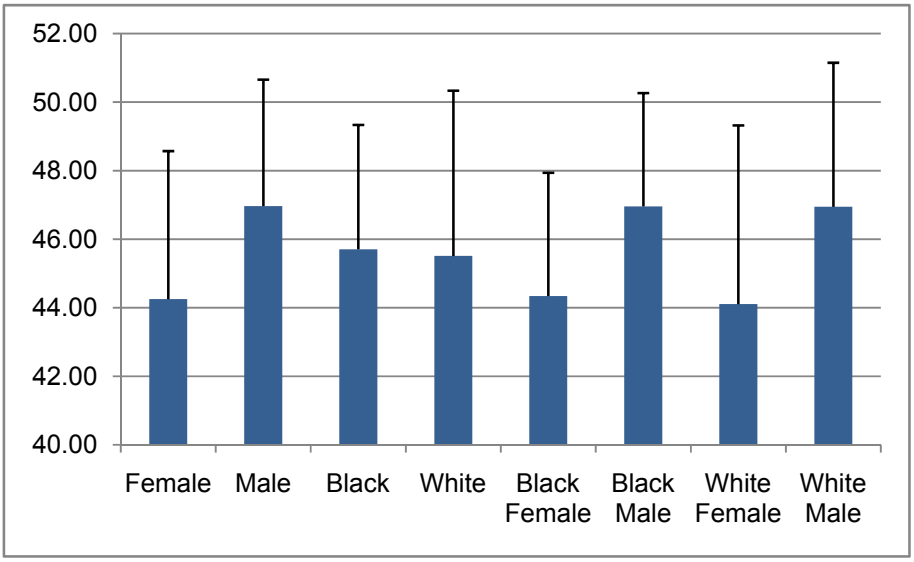
Graph 5.5 *The mean values (mm) and standard deviation (sd) for the angle on the left.*



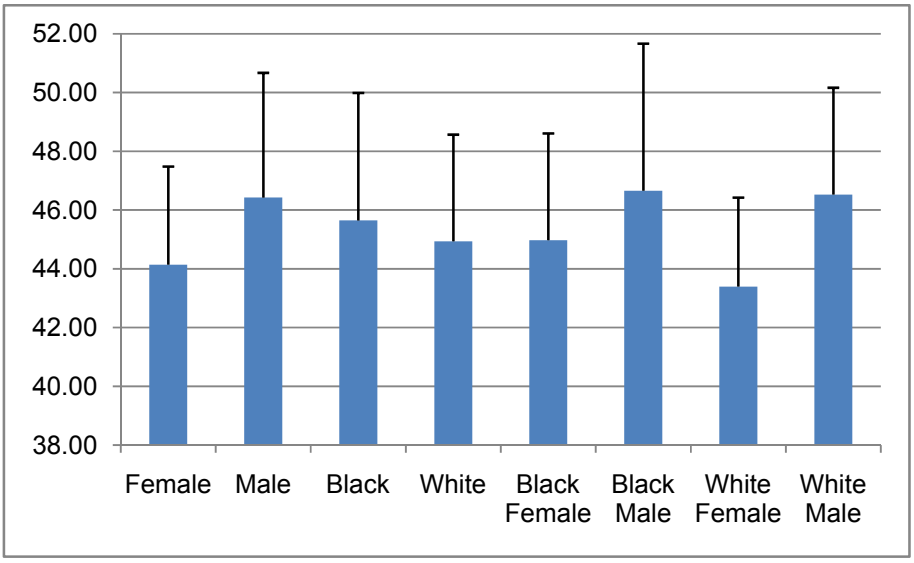
Graph 5.6 *The mean values (mm) and standard deviation (sd) for the angle on the right.*

The means (columns) and standard deviation (vertical lines) for the depth of the needle in the pterygopalatine fossa on the left and right is shown in graphs 5.7 and 5.8

respectively. The groups vary according to the values obtained. However, no significant differences were found for either of the sides. There seems to be a great difference between the values obtained for left and right, with the left measurements being the larger of the two. However, an unpaired t-test reveals that these differences are not significant (p=0.394).

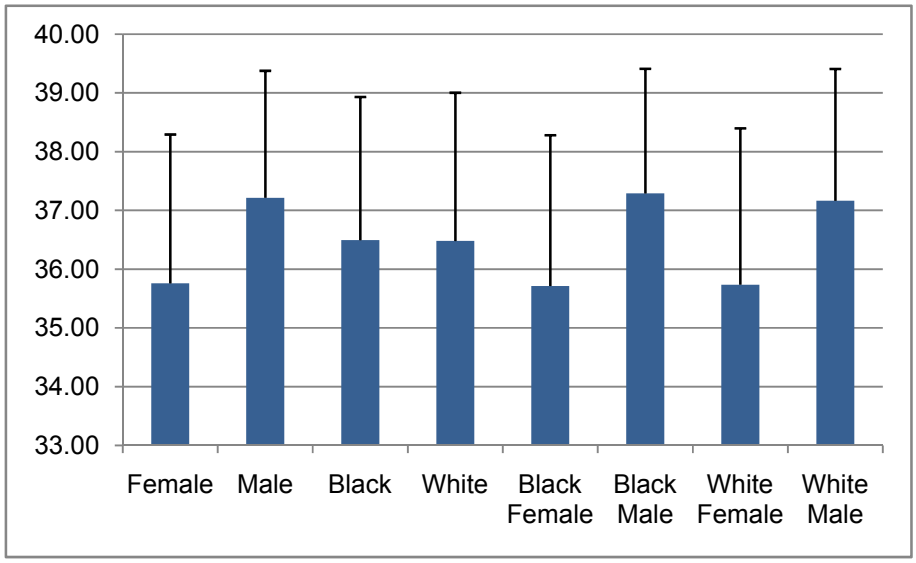


Graph 5.7 *The mean values (mm) and standard deviation (sd) for depth on the left.*



Graph 5.8 *The mean values (mm) and standard deviation (sd) for depth on the right.*

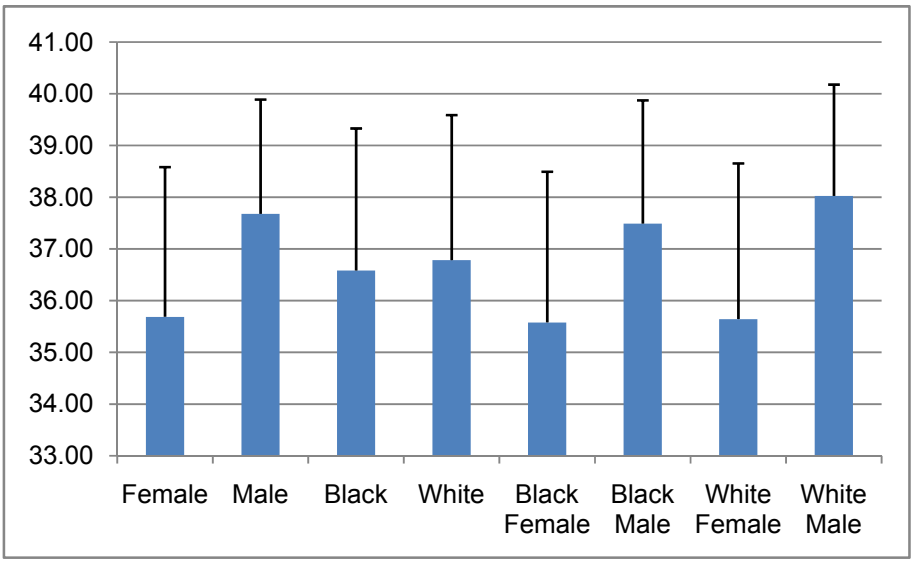
The means (columns) and standard deviation (vertical lines) for measurement C on the left is shown in graph 5.9. There appears to be a large difference between the measurements obtained for the different groups and p-values confirmed that the differences between males and females in the same population was significant for whites (p=0.01) and blacks (p=0.008). The differences within the sexes were not significant (p=0.984 for males and p=0.969 for females).



Graph 5.9 *The mean values (mm) and standard deviation (sd) for measurement C on the left.*

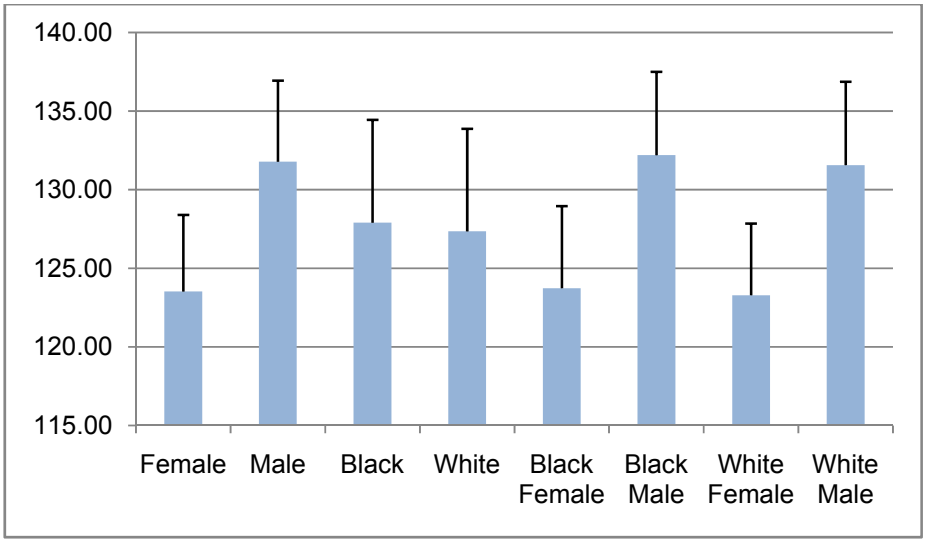
The means (columns) and standard deviation (vertical lines) for measurement C on the right is shown in graph 5.10. As was seen with the left side, there is a significant difference when comparing males to females in the same population (p=0.002 for blacks and p=0.001 for whites). When comparing the males and females between populations it was not significant (p=0.94 for males and p=0.365 for females). The left and right

measurements were very similar and this is confirmed by a p-value of 0.543 showing that there is no significant difference between the means for left and right.



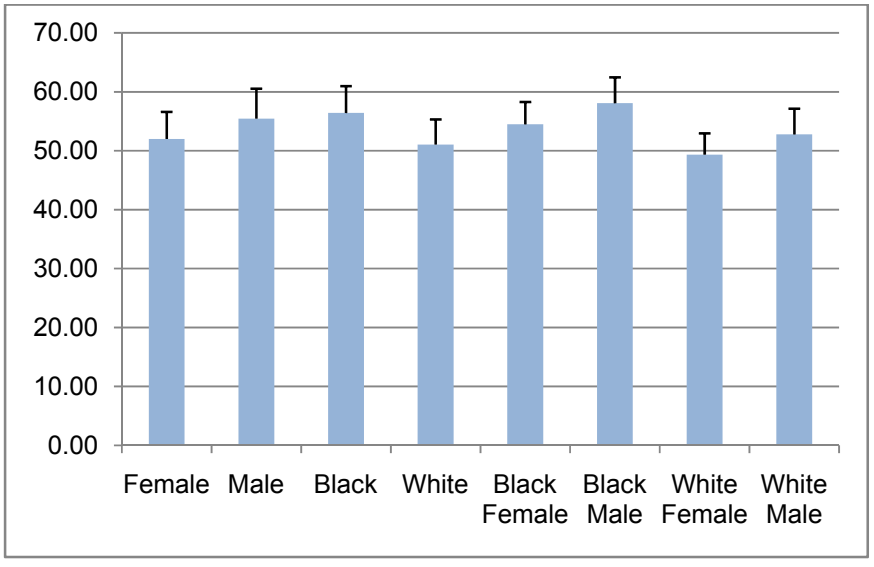
Graph 5.10 *The mean values (mm) and standard deviation (sd) for measurement C on the right.*

The means (columns) and standard deviations (vertical lines) for bizygomatic breadth in the different groups analysed can be seen in graph 5.11. It is evident that there is a sex difference with p-values equal to zero for both blacks and whites. The differences when comparing males and females of different populations are not significant (p=0.337 for males and p=0.814 for females). These differences were further confirmed when a t-test for sex differences overall yielded a p-value of zero and the t-test for population yielded a p-value of 0.599.



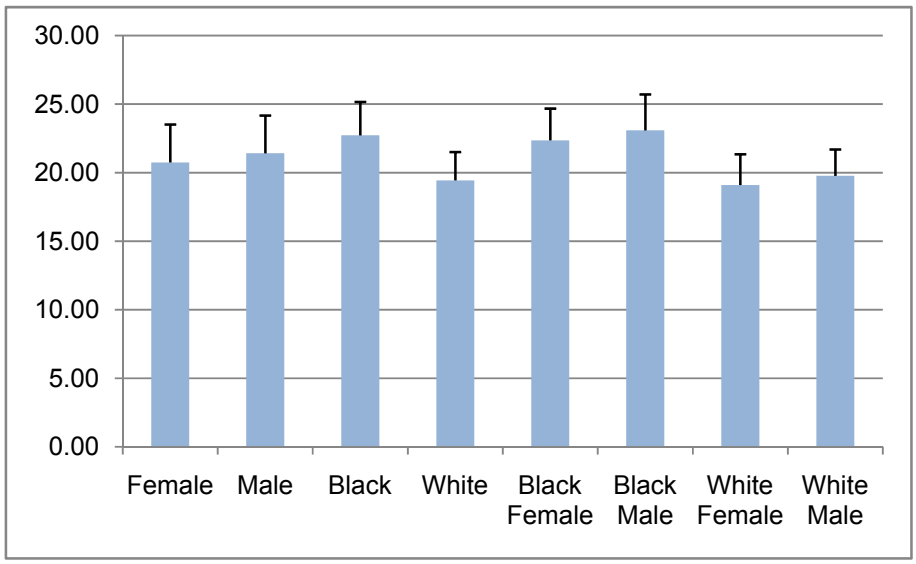
Graph 5.11 *The mean values (mm) and standard deviation (sd) for bizygomatic breadth.*

The means (columns) and standard deviation (vertical lines) for the bi-infraorbital foramen breadth in the different groups analysed is shown in graph 5.12. The differences for all groups were significant (range p=0 to 0.001).



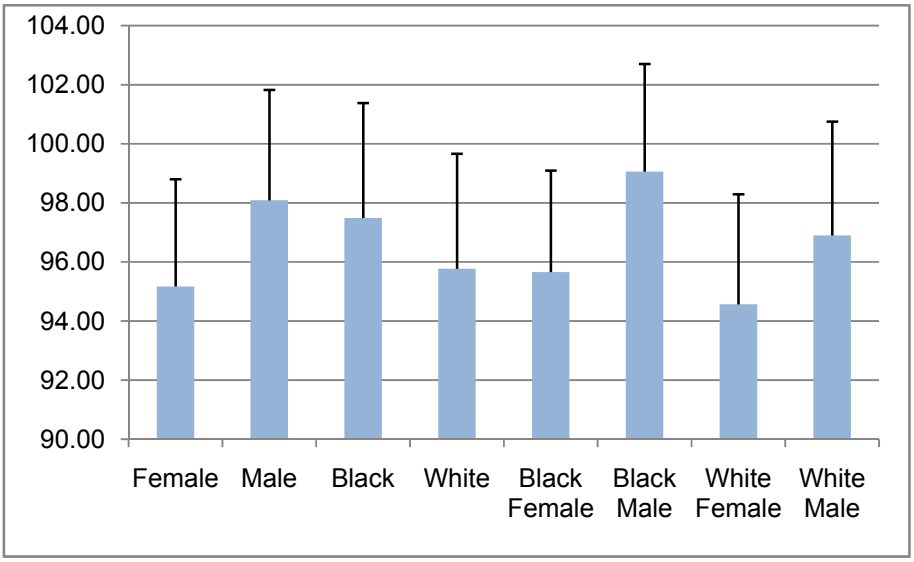
Graph 5.12 *The mean values (mm) and standard deviation (sd) for bi-infraorbital foramen breadth.*

The means (columns) and standard deviation (vertical lines) for the biorbital breadth in the different groups analysed is depicted in graph 5.13. From the graph it is clear that variation of the means is quite small, a t-test yielded non-significant p-values for sex differences in the same population (range p=0.098 to 0.233). However it seems there are significant differences between populations (p=0) on all tests.



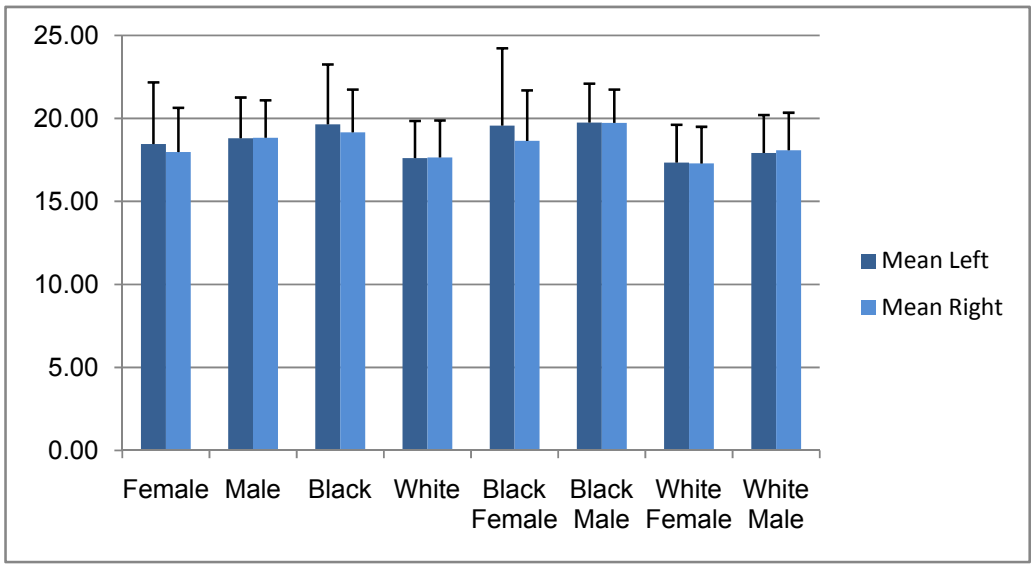
Graph 5.13 *The mean values (mm) and standard deviation (sd) for biorbital breadth.*

The means (columns) and standard deviation (vertical lines) for the least frontal breadth in the different groups analysed is seen in graph 5.14. There are significant differences between the groups when compared in the same manner as in the measurements above. Only when comparing males from different populations did the t-test yield a p-value above the significant level (p=0.082). These differences are both sex and population related (range p=0 to 0.014).



Graph 5.14 *The mean values (mm) and standard deviation (sd) for least frontal breadth.*

The means (columns) and standard deviation (vertical lines) for the calculated index is shown in graph 5.15 for right (light columns) and left (dark columns). From the graph it is clear that there is great overlap between the groups.



Graph 5.15 *The mean values (mm) and standard deviation (sd) for calculated index.*

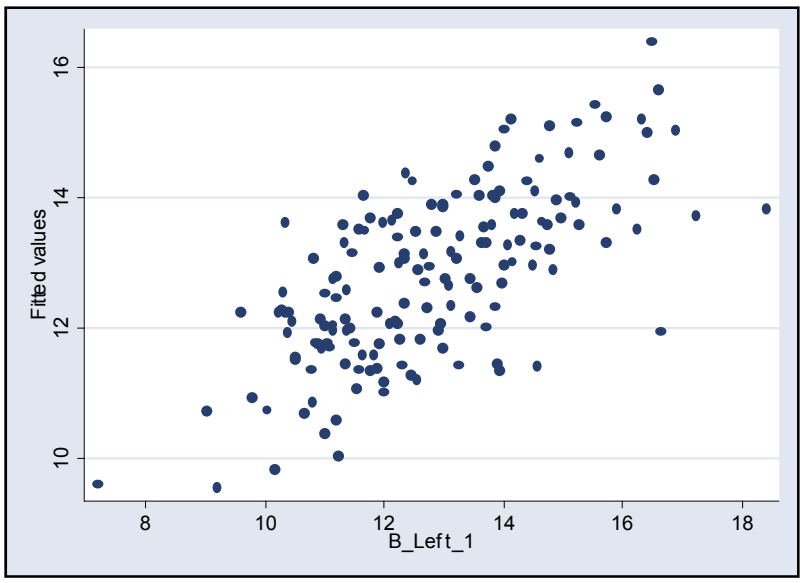
Graph 5.16 is an illustration of the percentage of error when the measurements were repeated. The highest error was with the angle and depth measurements. This can be explained by the variability of taking the measurement. Measuring of the angle is dependent on where the needle is placed and how it is held, as the angle was measured from the needle entry point. The angle and depth where both very variable and measurements differed even when taken a few minutes apart. This did not pose a problem, as the angle cannot be measured in a patient before placing the needle. To compensate for this variability, the means for each group was determined according to sex and race. The high accuracy of the intra-class correlation on the remaining measurements shows that it will be possible to perform the procedure without prior training or experience.

***Graph 5.16**. The intraobserver error percentage for measurements A and B on the skulls as well as the depth and angle.*

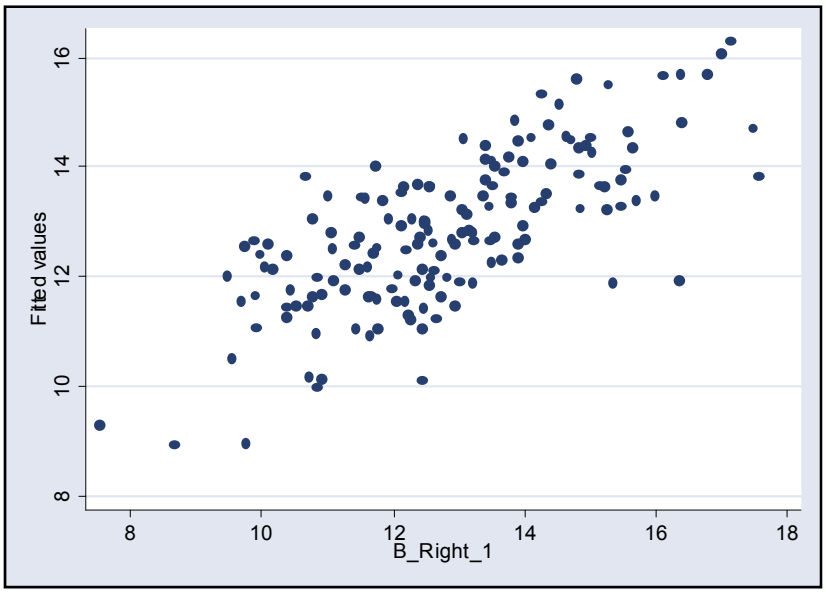
Table 5.3 *P-values and constants obtained in the regression analysis to indicate strength of influence each variable had on measurement B.*

Variable	P-value Left	P-value Right
Age	0.748	0.667
Race	0.000	0.000
Sex	0.422	0.257
Measurement A	0.024	0.015
Measurement C	0.000	0.000
BZB	0.671	0.602
BIOFB	0.956	0.323
LFB	0.203	0.532
IOB	0.751	0.645
Constant	0.176	0.129

As seen in graph 5.17 and 5.18 there is low correlation between the estimated values of measurement B and the actual measured values on the left and right respectively. The accuracy of the estimation further stresses this with ±45 percent on the left and ±50 percent on the right.



Graph 5.17 *Scatter graph for the distribution of the estimated value of measurement B on the left.*



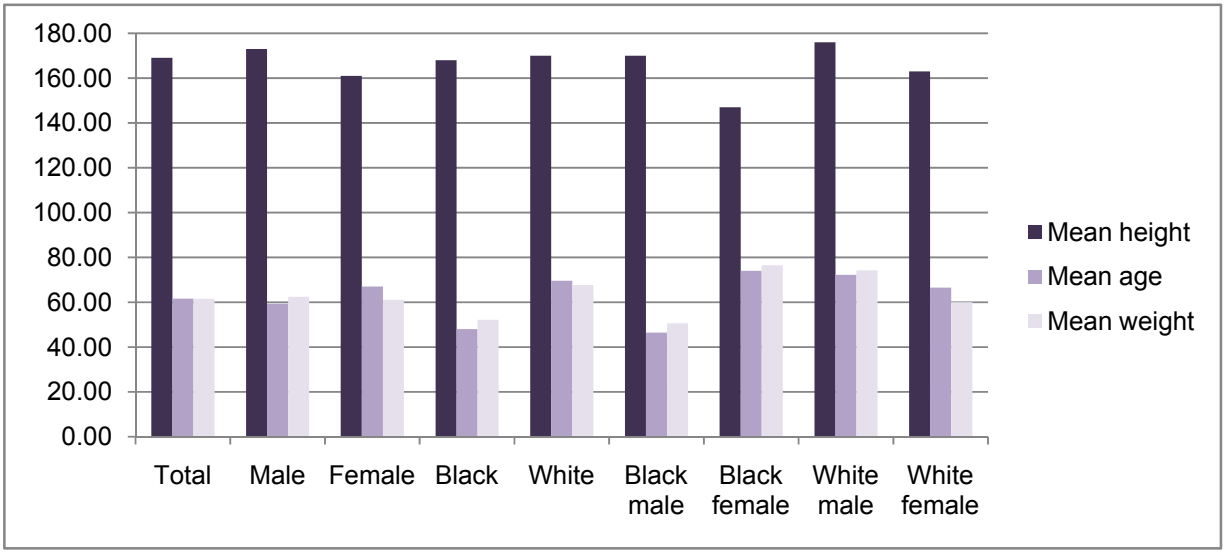
Graph 5.18 *Scatter graph for the distribution of the estimated value of measurement B on the right.*

5.2 Results from the Cadaveric study

The demographics for the Cadavers used in this study is shown in Table 5.4 and illustrated in graph 5.19. The mean age, height and weight were determined for each group. The highest recorded mean age was that of black females 74.0 years and the lowest was that for black males 46.4 years. The mean weight (kg) ranged from 50.6kg to 76.5kg with black females having the highest and black males the lowest. White males were the tallest with a mean height of 176cm, while black females were the shortest with a mean height of 147cm. It is important to note that the accuracy of measurements may be obscured depending on the time at which they were taken. The data above is included merely for completeness and possible repeatability as it was not used in the study. It is also a known fact that stature and weight changes during the embalming and preparation for dissections.

Table 5.4 *Demographics of the South African cadaver population used in this study.*

	Number	Mean age (years)	Mean height (cm)	Mean weight (kg)
Total	47.00	61.63	169.00	61.50
Male	31.00	59.34	173.00	62.44
Female	15.00	67.00	161.00	61.13
Black	17.00	48.06	168.00	52.16
White	30.00	69.57	170.00	67.61
Black male	16.00	46.44	170.00	50.64
Black female	1.00	74.00	147.00	76.50
White male	16.00	72.25	176.00	74.25
White female	14.00	66.50	163.00	60.03



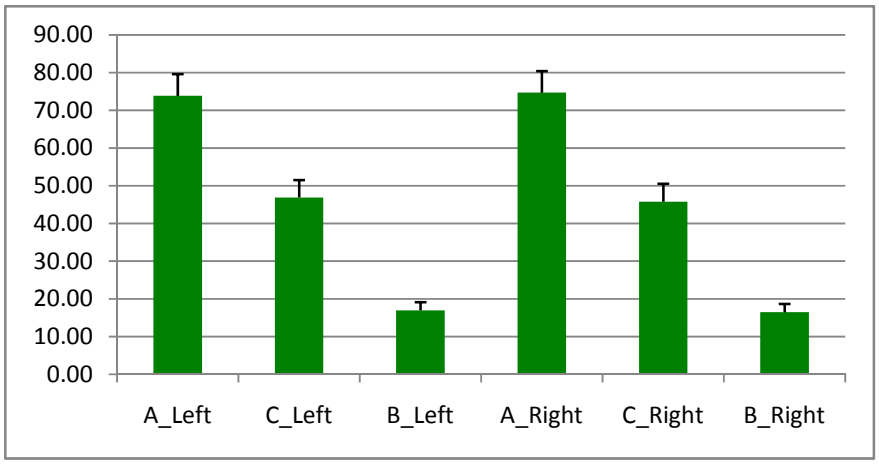
Graph 5.19 *The demographics of the South African cadaver population used in the study. The mean height is recorded in cm, mean age in years and mean weight in kg.*

The means (mm) of the measurements obtained from the cadavers, as well as the estimated value for measurement B for left and right is shown in table 5.5 and graph 5.20. From the graph it is apparent that there is not much difference between the measures for left and right. This might be due to the presence of soft tissue as there was a greater difference in the anthropometric study. The differences were not

significant and this was confirmed with a t-test. The p-values were 0.5, 0.2 and 0.2 for measurements A, C and B respectively.

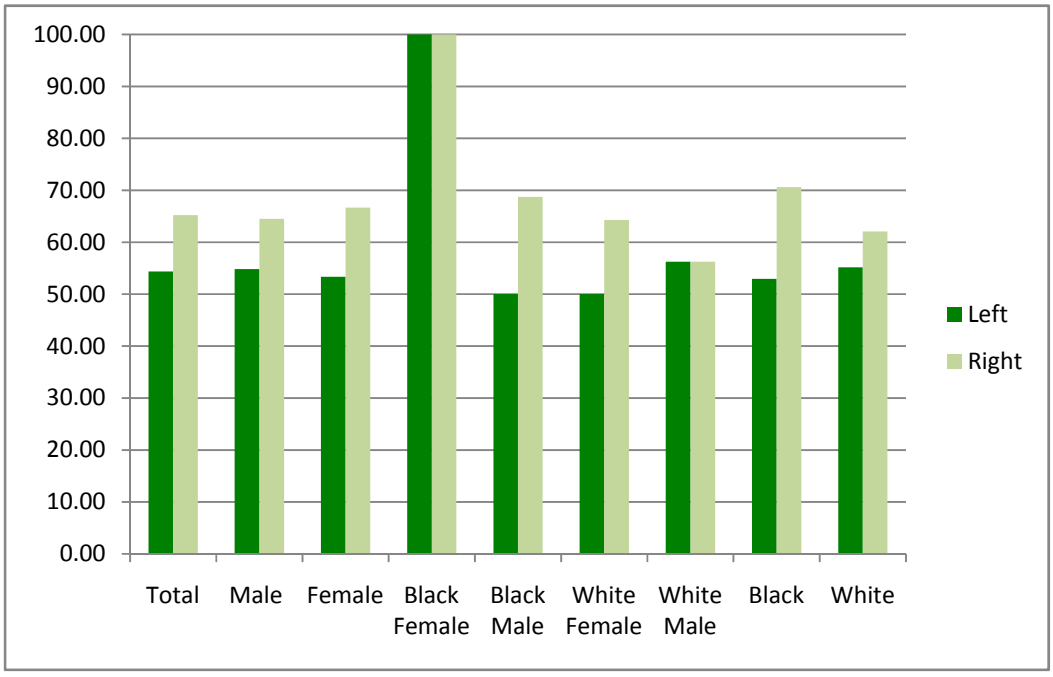
Table 5.5 *Mean (mm) and standard deviation (sd) of measurement A and C taken on the cadavers and measurement B that was calculated from A and C for the different groups.*

	A_Left	C_Left	B_Left	A_Right	C_Right	B_Right
Total	71.19	45.23	16.36	71.98	44.15	15.87
	5.78	4.60	2.14	5.73	4.77	2.18
Male	75.72	48.15	17.79	76.48	46.45	17.05
	5.27	4.78	1.94	5.34	4.69	2.10
Female	69.87	44.26	15.20	70.92	44.31	15.19
	4.84	2.79	1.37	4.70	4.77	1.84
Black Female	77.32	45.60	17.65	76.73	46.22	17.59
	n/a	n/a	n/a	n/a	n/a	n/a
Black Male	76.69	47.42	18.26	78.40	47.13	18.09
	5.62	3.85	1.47	4.63	5.50	2.06
White Female	69.34	44.17	15.03	70.50	44.17	15.02
	4.54	2.87	1.23	4.58	4.92	1.78
White Male	74.74	48.88	17.32	74.57	45.76	16.00
	4.86	5.60	2.26	5.44	3.76	1.59
Black	76.73	47.31	18.22	78.30	47.08	18.06
	5.45	3.76	1.43	4.50	5.33	2.00
White	72.22	46.68	16.25	72.67	45.02	15.54
	5.39	5.06	2.17	5.38	4.34	1.72

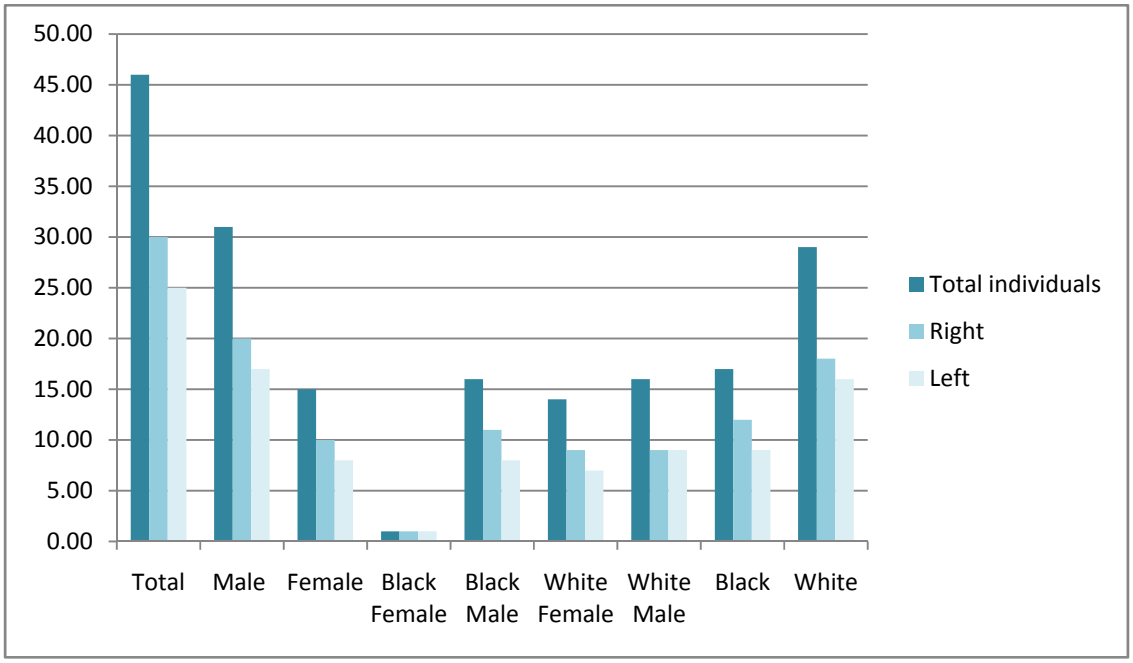


Graph 5.20 *The mean values (mm) and standard deviation (sd) of measurements used on cadavers.*

As with the anthropometric data, the accuracy of predicting measurement B (or in other words the location of the fossa) was higher on the right than on the left. This is illustrated in graph 5.21 which shows the percentage and graph 5.22 which shows the actual number of accurate needle placements for each group against the total number of individuals. From graph 5.21 it can be seen that the accuracy in locating the pterygopalatine fossa in the black female group is 100 percent. However, this is an untrue representation as the group consisted of one individual only. An interesting finding is that both the black female group and the white male group had the same accuracy on both sides. When using the values in graph 5.22 it is clear that there is no significant difference between the different groups as Fisher's exact test gives p-values of 0.5 to one.



Graph 5.21 *The incidence in percentage (%) in inserting the needle into the PPF for the different groups.*



Graph 5.22 *The number of times the PPF was entered in each group. Total is N=47.*

Unfortunately, the placement of the needle was not as simple as taking the measurements and placing them into a formula. At times, anatomical variation to the bony landmarks around the entry point prevented smooth insertion of the needle. However, even in cases such as these, the most variable factors were still the depth and angle at which the needle was inserted. Table 5.6 shows the values for the cases described.

The following changes occurred during initial placement of the needle:

(a) In six cases on the left and two cases on the right, the predicted distance to the fossa had to be adjusted due to the zygomatic process of the maxillary bone being too wide.

(b) The angle was adjusted for six cases on the left and four on the right.

(c) The depth was adjusted in four cases on the left and five cases on the right. However, in many more cases, the initial depth that was required was not achieved. This was overcome by slightly adjusting the needle so that it points in a more inferior and posterior direction. This improved the smooth advance and aided the placing of the needle at the required depth in most cases.

(d) In two cases the needle was advanced too deep on the right, which meant that the needle entered the fossa but was embedded into the medial wall.

(e) In three cases on the left and one on the right, the needle remained at the entrance of the fossa suggesting that the initial depth was too shallow.

(f) The pterygomaxillary fissure was the endpoint for one case on the left and seven cases on the right.

(g) For most cases in which the needle did not pass into the fossa the needle tip was found in close proximity of the pterygopalatine fossa or pterygomaxillary fissure however, in three cases on the left and one on the right it was very far off. The cases on the left was located two in the orbit due to the brittleness of the bone and one on the pterygoid plate, on the right the needle was located on the maxillary bone.

Table 5.6 *Measurements (mm) that differed from the calculation when needle was inserted is shown in bold.*

Spec_N	Angle_L		Depth_L		B_Left		Angle_R		Depth_R		B_Right	
6697	19.73	**16.00**	46.96	**50.00**	17.93	**17.31**	19.06		46.66		18.76	
6674	20.03		44.11		16.17	**17.01**	22.03		43.39		14.67	
6708	18.78	**37.50**	46.95		17.73		19.50	**22.00**	46.53	**30.00**	16.45	
6692	19.73		46.96		19.28	**20.39**	19.06		46.66	**40.00**	19.40	
6704	19.73	**30.00**	46.96		18.06		19.06		46.66	**30.00**	16.34	
6694	20.03	**40.00**	44.11		13.48		22.03		43.39		12.36	
6673	20.03	**13.19**	44.11		13.16		22.03	**30.00**	43.39		13.87	
6676	18.78		46.95		19.46		19.50		46.53		16.77	**20.17**
6683	19.73		46.96		17.61	**18.86**	19.06		46.66		17.79	
6677	20.03	**33.00**	44.11		14.73		22.03		43.39		15.23	
6703	19.73		46.96		18.46	**23.20**	19.06		46.66		17.49	
6696	18.78		46.95	**42.00**	18.89		19.50	**22.00**	46.53		17.80	
6707	19.73	**45.00**	46.96		17.26		19.06		46.66		18.23	

6. Discussion

The results obtained from the cranial measurements shows that measurements A and C had a significant effect on the outcome of the location of the pterygopalatine fossa. The third and most significant factor with a p-value of 0 was population affinity. Due to the known differences in morphology between different populations, it was decided to include this when the formulae for locating the pterygopalatine fossa was created. Using regression analysis, the pterygopalatine fossa can be located in its correct position to accuracy of 46.3 percent on the left and 51.3 percent on the right, when the factors that differ significantly from the mean are omitted.

For the purpose of this study the fossa needed to be located as accurately as possible to reduce the need of radiographic aids which makes procedures such as the proposed pterygopalatine block unnecessarily costly. The mean values of the measurements for male and female varied in that all the values for males were slightly higher, though not significantly so, than females, except for the angle at which the needle was inserted. Between the two populations, the means of Measurement A and Measurement C for blacks were higher than those for whites and correlates with the wide palate and lateral projecting zygomatic arches found in South African black individuals.[43] The results from the anthropometric study tied in well with the results from the test on the cadavers. An accuracy of 54.35 percent was achieved on the left and 63.04 percent on the right almost 10 percent higher than the accuracy of the regression analysis. The higher accuracy in the cadaver study could be attributed to soft tissue presence in the cadavers and provides grounds for using population as an indicator, as there are definite differences in soft tissue thickness between populations.[43]

Unfortunately, no previous studies have been done on finding the pterygopalatine fossa with formulae and can therefore not be compared to previous work.

One limitation of the current study is that it only tested between South African blacks and whites even though there might be other populations e.g. American blacks or European whites that could be encountered in practice. It is advisable that other populations be tested before this technique is readily employed by anyone. Should the population group be omitted from the formula it would drastically decrease the accuracy of the procedure as the regression analysis clearly indicated its significance. It is possible that other factors may influence the location of the pterygopalatine fossa in populations other than those found in South Africa.

Another factor to consider is the validity of two formulae. Slight differences were noted between left and right sides, but these were not statistically significant. The overall accuracy between left and right also differs which could validate the existence of two formulae. During the second part of the study where the formulae were tested the predicted measurement had to be altered to accommodate for the zygomatic bone in six of the 47 cadavers. Five of the six were altered on the right and one on the left side. If changes had to be made on one side only it would have been grounds for rejecting one of the formulas. But as changes needed to be made on the right and left side the formula was valid.

The technique investigated in this study is easy to apply, and once perfected, will not need the aid of radiography. Two other important factors to consider are the depth and angle at which the needle is inserted. It is believed that the reason for the low

accuracy during the test of the formulas on the cadavers in this study is due to the method of determining the angle and depth at which the needle was inserted. Because the angle and depth at which the pterygopalatine fossa is located in a patient cannot be determined before the needle is inserted, it was decided to use the mean values obtained for each group from the anthropometric study.

The sex and population affinity of the cadaver was determined and the mean angle and depth from the anthropometric study was used. As individuals within a population differ with regards to facial morphology, it could be possible that there is a link between the measurements used in the study and the angle and depth of the pterygopalatine fossa. Another possible reason for the inaccurate depth in the cadaveric study is that no compensation was made for skin thickness as it was thought to be negligible. From the results of the intra-observer error, it is obvious that both the angle and depth are the two most inconstant features and even the same individual will measure these with a low accuracy. For the other measurements the accuracy of the repeated measurements ranged between 85 and 95 percent.

As many of the methods for gaining access to the pterygopalatine fossa are reported as case studies based on trial and error, it is difficult to compare accuracy of previous methods. The accuracy of previous methods was also based on clinical findings such as loss of sensation to the areas supplied and can therefore not be compared to a study on cadaver material. However, Singh and co-workers[58] reported that in 65.3 percent of patients in which they performed the maxillary nerve block via an inferior zygomatic approach, pain was alleviated successfully. The accuracy of finding the pterygopalatine fossa in this study was lower when compared to that of Singh and

coworkers.[58] It might be possible that the method described in this study will have a higher accuracy in a clinical setting.

Singh and co-workers[58], described a similar approach to the pterygopalatine fossa as being performed from a lateral aspect which is performed by inserting a needle inferior to the zygomatic arch at the approximate midpoint to a depth of 4 to 5 cm until the tip of the needle contacts the lateral pterygoid plate.[58] The depth that was used in this study lies within the same range and provides substantiation to use such depths. Although the current study measured to the approximate midpoint of the fossa and used a suprazygomatic entry it can be compared with the infrazygomatic entry and the depth should be similar due to the small amount of soft tissue around both areas.

When the two methods are compared, it seems that the main factor of variability is in fact the angle at which the needle is inserted and not the depth. However, in many of the cases in which the needle did not enter the fossa, the tip of the needle was located at either the entrance to the fossa or close to the pterygopalatine fissure. This indicates that these two factors might not pose such a challenge in clinical practice as even though the pterygopalatine ganglion is described as being inside the pterygopalatine fossa. It is possible that the anaesthetising agent will enter the fossa even if the needle is not in the fossa itself. If the tip of the needle is positioned close to the pterygopalatine fissure, it would be possible to block the maxillary nerve independent from the pterygopalatine ganglion, a desired technique for dental surgery.[20]

The most common method of anaesthetising the maxillary teeth is by a simple infiltration injection in the buccal sulcus adjacent to the tooth.[20] Unfortunately, the majority of these blocks are incomplete and completely inadequate for hard tissue procedures.[20] There are several cases in which the block of the maxillary nerve as a whole is required in much the same way that it is found with the mandibular nerve block.[20] This hurdle might be overcome by the formulae developed in this study. Further studies should be done to test the technique in a clinical setting and with a slight alteration of the angle at which the needle is inserted, the maxillary nerve and pterygopalatine ganglion could be blocked independently.

Dentists generally receive patients with pain that cannot simply be treated with infiltration methods, and they are often faced with acute apical abscesses accompanied by facial swelling.[20] This poses unique challenges, because an infiltration injection might need to pass through the infected area and may cause severe secondary infection along the needle track.[20] A single administration of anaesthetic is favoured when working on multiple teeth in the same arch or area.[20] Although this is regularly achieved for dental procedures on the mandibular teeth, there is no evidence of such a block for the maxillary teeth and multiple blocks are still widely used.[20] As blocking the mandibular nerve close to its exit from the cranial cavity is highly effective, the same should be true for the maxillary nerve. If the nerve could be blocked before any branches are distributed, it would block the complete area of innervation. This is what the pterygopalatine block via the lateral

suprazygomatic approach as investigated in this study is aimed at – blocking the nerve along with the ganglion associated with it.

The vascular structures that are found within the pterygopalatine fossa usually lie anterior to the neural structures.[55] The third part of the maxillary artery (or more precisely, the distal third of the maxillary artery) is associated with the pterygopalatine fossa.[55] Three terminal branches exit the fossa via different foramina, the pharyngeal artery via the palatovaginal canal to the nasopharynx, and the posterior nasal and sphenopalatine via the sphenopalatine foramen.[55] The course of the maxillary artery in the pterygopalatine fossa is described as being tortuous and variable, but it is well-known that it lies in the fat anterior to the nervous structures.[55]

The anatomical location and course of the maxillary artery described above is advantageous to the method proposed by this study, since it should avoid serious complications that could arise by a needle piercing the vascular walls. The needle entry and advance in the present study is aimed at the posterior aspect of the neural structures found in the fossa and therefore no extra precautions need to be taken in order to avoid damage to the vessels. It is still advisable that the syringe is aspirated before injecting the anaesthetising agent to avoid complications due to unexpected anatomical variation in the vascular structures.

Many of the previously described methods of pterygopalatine block does not mention the relation of the needle relative to the location of the artery, but due to the common incidence of haemorrhage, it is apparent that this feature was not taken

into account previously. Neural structures that are found in the pterygopalatine fossa are located posterior to the blood vessels and include the nerve of the vidian canal, the maxillary division of the trigeminal nerve, the pterygopalatine ganglion, and the greater palatine nerve.[55] The nerve of the vidian canal enters the pterygopalatine fossa inferomedially to foramen rotundum via the pterygoid canal and is found posterior to the ganglion.[55]

7. Conclusion

The technique proposed in the present study serves as an alternative method of approach in locating, as accurately as possible, the pterygopalatine fossa and its accompanying ganglion. This procedure could change the way dentists and clinicians approach maxillary nerve blocks and treatment of trigeminal neuralgia, as well as other facial pain syndromes. This study indicates that it is possible to locate the pterygopalatine fossa using measurements of easily identifiable landmarks and substituting it into two formulae. As the formulae will calculate the location of the pterygopalatine fossa in a specific individual, it will provide easy access to the fossa as well as the structures located in and around it. Although more research is needed with regards to the soft tissue structures around it, the technique is theoretically a success. The proposed alternative method of locating the pterygopalatine fossa in this study is efficient, effective and possibly less damaging to surrounding tissues and would likely reduce pain to the patient. Many of the other techniques described in the literature (however vague) were almost always accompanied by reports of excruciating pain during the procedure. With further investigationand clinical trials, the technique could become everyday practice. This technique could be applied to patients undergoing dental surgery and also in patients where there is a need to manage chronic facial pain.

8. References

1. Dirckx JH, editor. Steadman's concise medical dictionary for the health professions. 4th ed. USA: Lippincott Williams & Wilkins; 2001. p 719.
2. Beers MH, editor. The Merck Manual of Medical Information. 2nd Home ed. USA: Pocket books; 2004. p 402-410.
3. Fauci AS, Braunwald E, Isselbacher KJ, Wilson JD, Martin JB, Kasper DL, *et al*. Harrison's principles of internal medicine. 14th ed. New York: McGraw-Hill; 1998. p 53 (vol 1)
4. Adams RD, Victor M. Principles of neurology. 4th ed. New York: McGraw-Hill; 1989. p103-4.
5. Thomas RJ, McEwen J, Asbury AJ. The Glasgow Pain questionnaire: A new generic measurement of pain; development and testing. Int J Epidemiol. 1996;25:1060-7.
6. Keefe FJ, Lumley MA, Buffington ALH, Carson JW, Studts JL *et al*. Changing the face of pain: evolution of pain research in psychosomatic medicine. Psychosom med. 2002;64:921-38.
7. Sessle BJ. The neurobiology of facial and dental pain: present knowledge, future directions. J Dent Res. 1987;66:962-81.
8. Schwartz NE, Rosenberg S, So YT. Action at a distance: a lumbar spine tumour presenting as trigeminal neuralgia. Clin neuro and neurosurg. 2006;108;806-8.
9. Lorenz J, Minoshima S, Casey KL. Keeping pain out of mind: the role of the dorsolateral prefrontal cortex in pain modulation. Brain. 2003;126;1079-91.

10. Neto HS, Camilli JA, Marues MJ. Trigeminal neuralgia is caused by maxillary and mandibular nerve entrapment: greater incidence of right sided facial symptoms is due to the foramen rotundum and foramen ovale being narrower on the right side of the cranium. Med Hypotheses. 2005;65:1179-82.
11. Cheuk AV, Chin LS, Petit JH, Herman JM, Fang H, Regine WF. Gamma knife surgery for trigeminal neuralgia: outcome, imaging, and brainstem correlates. Int J Radiat Oncol Biol Phys. 2004;60: 537-41.
12. Detzel JE, Grelle AR. Trigeminal neuralgia, new treatment options for a well-known cause of facial pain. Arch Fam Med. 1999; 8:264-8.
13. Pannullo SC, Lavyne MH. Trigeminal neuralgia: neurosurgical management options. JADA. 1996;127:1635-9.
14. Turp JC, Gobetti JP, Arbor A. Trigeminal neuralgia versus atypical facial pain. A review of the literature and case report. Oral Surg Oral Med Oral Pathol Oral Radiol Endod.1996; 81:424-32.
15. Nurmikko TJ, Elridge PR. Trigeminal neuralgia-pathophysiology, diagnosis, and current treatment. Br J Anaesth. 2001;87:1 117-132.
16. Sarlani E, Grace EG, Balciunas BA, Schwartz AH. Trigeminal neuralgia in a patient with multiple sclerosis and chronic inflammatory demyelinating polyneuropathy. JADA. 2005;136:469-76.
17. Aryan HE, Nakaji P, Lu DC, Alksne JF. Multimodality treatment of trigeminal neuralgia: impact of radiosurgery, and high resolution magnetic resonance imaging. Clin neurosci. 2006;13:239-44.

18. Lopez BC, Hamlyn PJ, Zakrzewska JM. Stereotactic radiosurgery for primary trigeminal neuralgia: state of evidence and recommendations for future reports. J Neurol Neurosurg Psychiatry. 2004;75:1019-24.
19. Benoliel R, Sharav Y. Trigeminal neuralgia with lacrimation or SUNCT syndrome? Cephalalgia. 1998;18:85-90.
20. Ong KS, Keng SB. Evaluation of surgical procedures for trigeminal neuralgia. Aneasth Prog. 2003;50:181-8.
21. Vargese BT, Koshy RC. Endoscopic transnasal neurolytic sphenopalatine ganglion block for head and neck cancer. J Laryngol Otol. 2001;115: 385-7.
22. Labat G. Regional anaesthesia in dental care a plea for its standardization. J Dent Res. 1925;VI:149-62.
23. Zeltzer LK, Tsao JCI, Bursch B, Myers CD. Introduction to the special issue on pain: From pain to pain-associated disability syndrome. J Pediatr Psychol. 2006;1-6.
24. Gracely RH, Geisser ME, Gisecke T, Grant MAB, Petzke F, et al. Pain catastrophizing and neural responses to pain among persons with Fibromyalgia. Brain. 2004;127: 835-43.
25. Gregory RJ, Manring J, Berry SL. Pain location and psychological characteristics of patients with chronic pain. Psychosomatics. 2000;41: 216-20.
26. Benoliel R, Elishoov H, Sharav Y. Orofacial pain with vascular type features. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1997; 84:506-12.

27. Mongoni F, Ciccone G, Ceccarelli M, Baldi I, Ferrero L. Muscle tenderness in different types of facial pain and its relation to anxiety and depression: A cross sectional study of 649 patients. Pain. 2007;131:106-11.

28. Kimos P, Biggs C, Mah J, Heo G, Rashiq S, Thie NMR, Major PW. Analgesic action of gabapentin on chronic pain in the masticatory muscles: A randomized clinical trial. Pain. 2007; 127:151-60.

29. Atsu SS, Tekdemir I, Elhan A. The coexistence of temporomandibular disorders and styloid process fractures: A clinical report. J Prosthet Dent. 2006;95:417-20.

30. LeResche L, Mancl LA, Drangsholt MT, Huang G, Von Korff M. Predictors of onset of facial pain and temporomandibular disorders in early adolescence. Pain. 2006;129:269-78.

31. Camparis CM, Formigoni G, Teixeira MJ, Bittencourt LRA, Tufik S, Tesseroli de Siqueira JT. Sleep bruxism and temporomandibular dissorder: Clinical and polysomnografic evaluation. Arch Oral Biol. 2006;51:721-8.

32. Cuffari L, Tesseroli de Siqueira JT, Nemr K, Rapaport A, Paulo S. Pain complaint as the first symptom of oral cancer: A descriptive study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2006; 102:56-61.

33. Ito M, Sonokawa T, Mishina H, Sato K. Dural arteriovenous malformation manifesting as Tic douloureux. Surg Neurol. 1996; 45:370-5.

34. Majoie CBLM, Hulsmans FH, Verbeeten B, Castelijns JA, van Beek EJR , Valk J *et al*. Trigeminal Neuralgia: Comparison of two MR Imaging techniques in the demonstration of neurovascular contact. Radiology. 1997; 204:455-60.

35. Majoie CBLM, Verbeeten B, Dol JA, Peeters FLM. Trigeminal neuropathy: evaluation with MR Imaging. Radiographics. 1995;15:795-811.
36. Newton AV, Mumford JM. Lateral dominance, Pain perception and pain tolerance. J Dent Res. 1972;51(4):940-2.
37. Erbay, S.H., et al, 2006; Nerve atrophy in severe trigeminal neuralgia: Noninvasive confirmation at MR Imaging- initial experience. Radiology 238 (2), 689-692.
38. Meaney JFM, Miles JB, Nixon TE, Whitehouse GH, Ballantyne ES, Eldridge PR. Vascular contact with the fifth cranial nerve at the pons in patients with trigeminal neuralgia: detection with 3D imaging. A J R. 1994;163:1447-52.
39. Kondo A, Tanabe H. What should be done, what should not be done in microvascular decompression surgery? International congress Series. 2004;1259:353-6.
40. Shi-Ting Li, Qinggang Pan ,Nigtao Liu , Feng Shen , Zhong Liu , Yuhang Guan . Trigeminal neuralgia: what are the important factors for good operative outcomes with microvascular decompression? Surg Neurol. 2004;62:400-5.
41. Febrenbach MJ Illustrated anatomy of the head and neck. 3rd edition. Philadelphia: WB Saunders Company; 1996. p 218.
42. Meiring JH, Liebenberg SW, van Heerden L, Jacobs CJ, Vorster W, Scheepers et al. Human Anatomy JH Meiring et al. Pretoria. Van Schaik Publishers; 2000.
43. Steyn M, L'abbé EN, Loots M. Forensic Anthropology [CD-ROM]. Version 2.5. Pretoria: Telematic Learning and Education Innovation; 2004.

44. Moore KL, Persaud TVN. The developing human: clinically orientated embryology. 7th edition. Philadelphia: Saunders; 2003.
45. T.W Sadler, ed. Langman's Medical embryology. 8th edition. USA: Lippincott Williams & Wilkins; 2000. p161,p165-166, p346-349, p369-371.
46. Drake RL, Vogl W, Mitchell AWM. Gray's Anatomy for students. Spain: Elsevier Churchill Livingstone; 2005. p763.
47. Standring S. Gray's anatomy the anatomical basis of clinical practice, 39 edition. Edinburgh (NY): Elsevier, Churchill Livingstone; 2005. p578-9.
48. Moore KI, Dalley AF. Clinically orientated Anatomy. 4th edition. USA: Lippincott Williams & Wilkins; 1999. p950-1.
49. Choi J, Park H. the clinical anatomy of the maxillary artery in the pterygopalatine fossa. J Maxillofac Surg. 2003;61:72-8.
50. Gray SH, Carter HV. Gray's anatomy a facsimile. USA: Grange Books; 2005.
51. A.M.R Agur, M.J Lee. Grant's atlas of anatomy. Tenth edition. Canada: Lippincott Williams & Wilkins; 1999. p523-34.
52. Netter FH, Atlas of human anatomy. 4th edition. Philadelphia: Saunders Elsevier; 2006.
53. Daniels DL, Mark LP, Ulmer JL, Mafee MF, McDaniel J, Shah NC *et al*. Osseous Anatomy of the Pterygopalatine Fossa. AJNR. 1998;1423-32.
54. Marsot-Dupuch K, De Givry SC, Ouayoun M. Wegener Granulomatosis Involving the pterygopalatine fossa: An unusual case of trigeminal neuropathy. AJNR. 2002;23:312-5.

55. Statham MM, Tami TA. Endoscopic anatomy of the pterygopalatine fossa. Operative techiniques in otolaryngology. 2006;17:197-200.
56. Curtin HD, Williams R. Computed Topographic anatomy of the pterygopalatine fossa. Radiographics. 1985;5(3):429-40.
57. Bass WM, Human osteology, A laboratory and field manual. Missouri Archeological Society; 1995. p 62, p72-73.
58. Singh B, Srivastava SK, Dang R. Anatomic considerations in relation to the maxillary nerve block. Regional aneasth. 2001;26:502-11.

9. Appendix

The statistical analysis was carried out using multiple variant regression analysis with the following function:

Location of fossa = f(sex,race,age,LEmax-porion)+constant

Location of fossa = fs*sex+ fr*race+ fa*age+ fLEmax-porion*(LEmax-porion)+constant

Where the location of the fossa is the distance to the fossa from the point on the lateral border of the eye (landmark b) in other words measurement B (the predicted value), LEmax-porion is measurement A and f is the coefficient for the respective variables. The values for sex and population was given a numerical constant; male=1, female=0 and black=1, white=0.

Table 9.1 *Measurements A, B and C as well as the angle, depth, bizygomatic breadth (BZB), bi-infraorbital foramen breadth (BIOFB), intraorbital breadth (IOB) and least frontal breadth (LFB) for white females.*

Spec_no	Age	A_Left_1	A_Right_1	B_Left_1	B_Right_1	Angle_L_1	Angle_R_1	Depth_L_1	Depth_R_1	C_L_1	C_R_1	BZB_1	BIOFB_1	IOB_1	LFB_1
4467	54	67.04	65.75	13.24	11.76	14.00	16.00	43.00	42.00	35.01	34.58	119.00	47.89	20.04	90.00
5299	86	63.06	61.93	11.23	12.44	25.00	20.00	45.00	44.00	32.37	33.00	121.00	54.68	18.35	92.50
5373	65	64.93	64.50	13.93	12.17	23.00	10.00	42.00	40.00	35.39	36.27	126.00	50.54	23.65	93.00
5408	76	61.73	64.72	11.76	12.04	24.00	25.00	45.00	42.00	36.26	36.17	120.00	49.84	20.98	98.00
5452	84	72.83	72.53	14.39	13.75	27.00	26.00	44.00	46.00	41.10	41.30	125.00	43.89	16.83	92.00
5456	54	66.83	67.63	10.66	10.53	15.00	22.50	40.00	39.00	33.07	35.18	125.50	49.73	17.72	92.00
5488	56	68.94	70.68	10.83	11.62	24.00	22.50	46.00	43.00	35.43	34.79	120.00	51.75	21.20	95.00
5553	60	65.82	66.49	12.45	12.94	18.00	26.00	42.00	42.00	34.96	35.45	124.50	55.00	20.80	92.00
5562	81	65.84	65.42	10.28	10.04	17.00	26.00	44.00	43.00	37.65	37.74	122.00	43.08	17.41	90.00
5575	87	64.94	68.27	11.88	11.74	21.00	19.00	46.00	41.00	35.50	35.29	120.00	47.52	20.00	90.00
5583	79	66.81	66.52	9.77	9.91	19.00	27.00	41.00	44.00	33.75	34.39	124.00	48.13	17.58	92.00
5594	69	65.54	68.30	11.00	10.71	12.50	18.00	42.00	42.00	32.54	31.41	116.00	49.77	17.71	96.00
5607	57	61.60	63.14	7.19	7.53	17.00	23.00	42.00	42.00	31.59	30.45	117.00	46.29	17.84	93.00
5612	69	74.02	70.95	10.38	9.90	16.00	22.00	49.00	47.00	35.29	34.75	130.00	51.36	18.09	98.00
5693	86	66.27	66.68	12.67	15.25	22.50	26.00	45.00	42.00	38.70	40.29	130.00	51.60	21.21	97.50
5716	67	66.52	66.74	11.13	10.38	20.00	17.00	45.00	46.00	36.85	35.36	121.00	52.34	23.18	99.00
5744	89	71.27	72.11	12.21	11.92	17.00	19.00	48.00	43.00	39.20	38.30	127.00	50.33	21.53	99.00
5758	76	67.99	67.84	11.33	11.98	21.00	29.00	47.00	45.00	34.77	35.97	122.00	50.41	17.69	89.00
5763	75	67.02	69.97	14.83	13.48	18.00	22.00	41.00	48.00	38.99	37.82	126.00	47.15	17.39	93.00
5769	74	63.20	66.00	11.63	10.92	18.00	17.00	43.00	42.00	36.56	36.21	122.00	46.08	19.11	92.00
5774	80	70.87	68.20	11.98	12.46	27.00	28.00	44.00	45.00	33.23	34.94	125.00	50.53	18.11	99.00
5806	77	68.89	71.26	13.08	13.90	21.00	24.00	51.00	48.00	37.86	36.55	129.00	54.25	22.36	105.00
5818	50	66.83	67.58	11.20	10.83	22.00	27.00	38.00	37.00	32.75	31.09	116.00	43.52	15.34	94.00
5895	57	64.29	65.72	9.59	9.97	22.00	20.00	45.00	45.00	38.04	38.31	122.00	45.26	18.18	90.00
5918	71	69.98	67.66	11.36	12.72	25.00	21.00	44.00	46.00	35.66	35.62	125.00	46.72	20.04	96.00
6064	48	65.50	63.80	11.32	10.09	25.00	17.50	68.00	42.00	40.56	39.36	123.00	52.20	18.16	93.00
6117	77	70.32	70.03	12.99	13.20	17.00	21.00	49.00	47.00	34.81	35.63	124.00	51.59	20.92	95.00
6208	78	68.10	65.15	13.63	12.63	20.00	20.00	42.00	50.00	39.86	37.67	124.00	50.46	19.72	96.00
6213	79	63.67	65.50	10.94	11.07	14.00	20.00	44.00	43.00	36.66	38.68	131.00	55.93	21.98	101.00
6215	69	64.45	63.81	9.19	8.67	20.00	23.00	41.00	41.00	30.62	29.25	115.00	50.62	16.98	94.00
6227	85	66.02	66.07	11.54	12.24	18.00	21.00	48.00	42.00	34.33	35.16	124.00	44.64	15.56	90.00
6246	77	59.95	60.21	9.02	9.54	27.00	28.00	39.00	37.00	35.13	34.59	116.00	39.82	15.93	89.00
6266	76	64.42	64.02	14.49	12.89	12.00	18.00	38.00	41.00	39.92	39.51	129.00	49.23	23.64	101.00
6293	48	65.58	67.19	11.19	13.54	20.00	20.00	40.00	45.00	39.18	42.32	122.00	47.11	18.01	96.00
6319	64	67.18	68.31	10.50	10.38	24.00	25.00	41.00	39.00	35.30	34.39	120.00	43.03	15.82	95.00
6322	81	62.95	66.05	10.03	10.92	16.00	27.50	43.00	42.00	34.30	31.89	118.00	52.10	19.82	95.00
6340	87	67.15	68.04	12.60	12.71	22.00	21.00	47.00	47.00	36.08	37.56	132.00	51.60	19.17	98.00
6347	56	64.86	62.20	10.16	9.76	22.00	25.00	35.00	46.00	31.26	29.76	123.00	54.00	16.72	91.00
6396	90	67.66	69.34	10.52	10.77	15.00	23.00	43.00	46.00	35.07	35.14	131.00	47.95	18.42	92.50
5442#		64.88	66.52	11.98	12.43	27.00	15.00	44.00	42.00	34.51	34.31	116.00	55.06	20.05	95.00

#Due to the number of years that some specimens were in the Pretoria Bone collection the age of many is not known, this did not influence the results of the regression analysis.

Table 9.2 *Measurements A, B and C as well as the angle, depth, bizygomatic breadth (BZB), bi-infraorbital breadth (BIOFB), intraorbital breadth (IOB) and least frontal breadth (LFB) for white males*

Spec_no	Age	A_Left_1	A_Right_1	B_Left_1	B_Right_1	Angle_L_1	Angle_R_1	Depth_L_1	Depth_R_1	C_L_1	C_R_1	BZB_1	BIOFB_1	IOB_1	LFB_1
3700	77	70.09	69.37	10.92	10.84	17.00	20.00	42.00	42.00	36.11	36.10	121.00	47.77	18.62	96.00
4006	94	69.98	68.14	10.78	11.43	19.00	16.00	48.00	44.00	33.98	33.91	130.00	55.38	20.67	100.00
4194	77	67.31	67.28	13.89	15.34	21.00	12.50	42.00	44.00	35.01	36.43	122.00	52.68	18.42	93.00
4377	58	67.49	67.62	13.84	13.55	26.00	21.00	51.00	48.00	37.33	38.61	139.00	53.53	21.18	100.00
4416	91	68.69	69.52	10.99	10.16	20.00	30.00	41.00	39.00	36.17	36.47	121.00	46.32	17.36	98.00
4481	78	68.86	69.31	16.89	15.56	19.00	23.00	42.00	47.00	44.36	43.51	133.00	61.57	23.61	98.00
4537	59	72.72	69.81	10.82	11.05	21.00	20.00	48.00	49.00	37.85	38.25	134.00	47.57	17.94	97.00
4754	71	71.64	69.96	15.11	15.98	22.50	20.00	48.00	49.00	40.78	40.06	139.00	50.10	20.34	99.00
4818	49	70.17	73.21	11.42	12.46	22.00	22.00	45.00	47.00	35.72	37.90	132.00	52.01	20.37	95.00
5127	78	72.73	73.33	13.43	12.33	15.00	13.00	48.00	46.00	35.44	34.80	134.00	57.45	20.88	98.00
5225	62	71.09	69.39	12.93	12.81	12.00	18.00	42.00	43.00	35.59	36.12	124.00	47.65	22.04	95.00
5325	77	70.91	68.58	12.92	13.49	12.00	12.50	42.00	52.00	35.35	37.10	137.50	55.62	18.22	96.00
5387	55	77.57	76.18	13.82	13.91	16.00	18.00	52.00	53.00	39.11	41.07	136.00	55.79	21.43	105.00
5434	80	70.17	70.32	13.26	12.48	26.00	20.00	51.00	50.00	39.52	38.66	133.00	51.52	21.67	97.00
5573	80	68.71	68.47	12.71	13.04	14.00	15.00	48.00	49.00	36.93	38.65	128.00	59.05	18.22	96.00
5592	74	71.46	74.96	12.28	13.22	18.00	14.00	44.00	44.00	33.77	36.41	131.00	49.09	18.65	89.00
5626	51	74.11	73.43	15.73	15.02	26.00	22.50	45.00	43.00	38.12	41.26	127.00	48.57	21.51	96.00
5641	76	64.09	63.81	12.09	12.26	21.00	20.00	43.00	42.00	37.58	35.58	119.00	52.54	19.53	90.00
5650	85	70.28	70.93	14.55	15.14	17.00	16.00	49.00	50.00	39.09	40.29	129.00	52.78	18.69	96.00
5677	73	69.50	71.13	10.33	10.37	20.00	20.00	45.00	47.00	36.49	36.70	130.00	59.12	16.55	98.00
5784	83	73.17	75.02	14.60	14.37	21.00	20.00	45.00	43.00	41.93	42.23	134.00	47.90	17.20	92.00
5799	80	71.67	71.74	12.24	11.84	20.00	18.00	52.00	49.00	37.99	39.30	136.00	57.95	22.67	103.00
5811	74	65.42	66.76	11.08	11.28	24.00	20.00	43.00	44.00	36.23	37.49	136.00	45.52	17.11	96.00
5817	63	73.63	75.94	13.69	13.14	14.00	17.00	43.00	49.00	34.76	36.68	135.00	54.49	22.61	101.00
5858	75	74.16	73.36	11.46	11.75	20.00	22.00	48.00	50.00	37.71	36.50	140.00	52.83	20.69	105.00
5909	64	73.52	72.90	10.22	10.67	17.50	25.00	46.00	44.00	35.43	40.21	131.00	53.43	21.88	99.00
5916	77	71.99	72.06	10.37	10.43	21.00	26.00	48.00	47.00	34.96	34.69	131.00	50.06	18.36	100.00
5924	69	75.54	72.87	13.59	13.68	17.50	19.00	50.00	45.00	39.72	40.45	136.00	58.19	21.84	101.00
6008	48	73.57	73.18	13.97	14.25	25.00	22.00	46.00	46.00	36.59	38.87	132.00	49.88	18.61	95.00
6219	67	70.33	71.64	11.92	12.37	15.00	27.00	40.00	40.00	34.98	37.14	131.00	58.32	19.45	95.00
6241	87	72.44	70.69	11.36	12.41	11.00	13.00	49.00	55.00	36.63	37.80	141.00	56.13	21.68	101.00
6288	70	71.19	70.74	12.21	13.66	25.00	22.50	48.00	49.00	35.56	36.62	136.00	57.42	21.04	99.00
6302	79	70.37	71.36	13.45	12.53	20.00	20.00	52.00	53.00	37.70	37.94	132.00	52.44	17.44	100.00
6307	70	73.81	72.86	12.34	12.11	8.00	20.00	62.00	45.00	37.58	37.75	129.00	56.97	21.66	93.00
6341	89	69.61	71.23	12.26	12.56	20.00	21.00	49.00	44.00	35.40	35.62	130.00	52.77	17.00	93.00
6348	61	70.79	68.16	14.02	13.45	15.00	14.00	51.00	44.00	38.16	40.02	127.00	47.58	19.06	92.00
6374	51	68.45	69.18	14.29	14.84	17.50	15.00	49.00	48.00	39.85	39.64	134.00	49.23	18.16	95.00
6385	80	69.72	69.67	11.48	11.48	17.50	20.00	45.00	44.00	35.21	36.43	128.00	52.87	20.26	96.00
5328#		75.79	73.83	12.99	11.68	25.00	15.00	47.00	47.00	39.26	36.12	132.00	51.12	18.41	94.00
5719#		69.72	69.10	11.93	11.60	21.00	23.00	48.00	47.00	38.39	36.72	135.00	49.69	21.19	101.00

#Due to the number of years that some specimens were in the Pretoria Bone collection the age of many is not known, this did not influence the results of the regression analysis.

Table 9.3 *Measurements A, B and C as well as the angle, depth, bizygomatic breadth (BZB), bi-infraorbital foramen breadth (BIOFB), intraorbital breadth (IOB) and least frontal breadth (LFB) for black females.*

Spec_no	Age	A_Left_1	A_Right_1	B_Left_1	B_Right_1	Angle_L_1	Angle_R_1	Depth_L_1	Depth_R_1	C_L_1	C_R_1	BZB_1	BIOFB_1	IOB_1	LFB_1
2615	58	70.27	68.42	11.13	11.42	15.00	16.00	46.00	45.00	34.31	34.68	120.00	51.24	19.68	91.00
2900	60	68.98	68.16	11.20	9.74	20.00	25.00	45.00	47.00	33.84	34.66	119.00	54.05	23.63	91.00
3154	40	70.49	70.78	10.30	9.47	20.00	16.00	47.00	46.00	33.66	32.49	125.00	58.39	22.66	101.00
3669	65	69.46	70.83	11.30	10.78	20.00	20.00	48.00	44.00	36.74	35.29	125.00	53.72	24.34	96.00
4239	60	70.68	71.67	15.90	15.69	22.00	12.00	42.00	43.00	37.09	36.03	125.00	62.88	24.46	94.00
4436	37	69.97	70.81	13.93	14.00	19.00	16.00	42.00	49.00	38.01	34.32	127.00	52.43	22.17	95.00
4442	35	63.44	63.97	11.03	11.08	24.00	15.00	50.00	48.00	33.55	34.10	120.00	53.83	23.70	96.00
4448	38	65.33	66.81	11.57	11.64	30.00	20.00	41.00	41.00	31.86	30.53	121.00	52.08	18.87	96.00
4486	48	68.92	69.91	12.86	13.37	24.00	22.00	44.00	46.00	36.66	36.77	130.00	62.60	23.53	96.00
4516	42	71.10	71.03	16.41	16.79	26.00	20.00	47.00	48.00	40.13	42.52	123.00	50.58	20.69	95.00
4521	50	66.67	68.75	13.52	13.97	25.00	19.00	48.00	44.00	39.43	38.77	121.00	51.93	23.34	96.00
4529	60	74.76	74.78	12.56	12.94	23.00	19.00	44.00	43.00	33.39	32.93	129.00	60.27	21.03	96.00
4598	32	63.91	71.44	11.82	12.28	19.00	16.00	49.00	49.00	32.88	35.21	135.00	60.27	21.73	94.00
5033	70	68.85	67.63	13.87	14.10	15.00	16.00	50.00	48.00	38.03	40.33	131.00	56.76	21.79	100.00
5079	45	61.84	62.06	14.18	13.98	28.00	27.00	39.00	40.00	39.40	37.48	113.00	47.73	17.90	97.00
5150	31	65.87	67.30	14.77	15.46	14.00	23.00	43.00	42.00	36.78	38.27	120.00	51.85	21.72	96.00
5156	41	79.74	81.86	15.71	15.27	17.50	19.00	49.00	50.00	38.35	39.00	126.00	54.39	21.40	94.00
5292	46	63.01	64.90	13.11	13.01	12.00	13.00	48.00	44.00	35.18	33.82	124.00	55.00	24.70	94.00
5319	70	64.58	63.85	12.74	12.43	29.00	19.00	43.00	42.00	36.41	34.72	119.00	48.70	20.69	98.00
5342	57	65.32	65.87	11.00	9.89	10.00	22.00	40.00	42.00	35.08	35.64	126.00	59.24	25.88	100.00
5390	65	64.77	67.00	10.79	11.28	18.00	18.00	45.00	44.00	30.67	32.82	120.00	57.36	23.33	99.00
5635	50	64.79	65.51	28.00	18.00	14.56	12.55	41.00	45.00	32.18	33.49	115.00	48.16	21.19	92.00
5692	44	69.74	68.69	10.44	9.68	19.00	17.00	39.00	49.00	32.61	31.75	122.00	57.07	23.18	95.00
5705	65	69.15	70.28	12.17	10.82	19.00	21.00	43.00	38.00	32.84	29.73	113.00	50.35	18.98	88.00
5892	26	68.63	70.30	12.33	13.11	22.50	22.00	46.00	47.00	35.75	35.74	124.00	54.68	22.42	101.00
6094	33	66.58	69.11	12.32	12.07	24.00	21.00	42.00	39.00	34.29	32.99	119.00	54.47	24.25	94.00
6139	38	69.78	69.08	13.22	13.04	26.00	27.50	42.00	46.00	35.29	36.27	127.00	51.83	19.11	98.00
6144	50	67.33	66.64	11.97	11.48	17.00	9.00	42.00	52.00	37.47	35.62	126.00	59.24	26.95	92.50
6156	65	68.38	67.26	11.13	10.70	29.00	26.00	45.00	42.00	32.65	31.94	124.00	51.50	18.90	96.00
6157	30	64.46	64.58	14.14	13.90	19.00	25.00	37.00	37.00	36.63	35.87	120.00	51.20	21.89	90.00
6172	53	67.72	68.72	16.64	16.35	21.00	20.00	42.00	49.00	32.79	32.81	121.00	54.93	22.04	93.00
6192	22	68.33	72.38	11.76	12.12	16.00	17.00	51.00	43.00	37.34	36.22	124.00	55.58	26.28	94.00
6237	56	67.39	66.27	13.75	13.07	19.00	18.00	45.00	45.00	39.77	40.69	124.00	51.69	21.68	100.00
6290	24	65.52	67.18	11.64	11.00	16.00	18.00	40.00	43.00	39.07	37.52	125.00	53.02	22.16	93.00
6315	64	71.73	73.17	17.23	15.65	26.00	18.00	44.00	49.00	36.49	38.22	128.00	53.11	22.06	97.00
6328	47	74.19	72.99	14.01	14.25	27.50	21.00	41.00	44.00	39.41	41.03	138.00	59.15	27.52	106.00
6370	60	66.82	67.65	11.86	12.60	17.50	20.00	44.00	44.00	33.83	35.02	124.00	55.47	19.25	95.00
6388	47	67.40	79.17	13.66	13.40	15.00	25.00	51.00	52.00	37.28	36.65	129.00	54.01	24.50	95.50
1636*	48	68.86	70.87	14.07	13.39	26.00		44.00		36.08	37.28	126.00	58.62	23.19	98.00
3394#		70.15	75.05	12.97	13.85	23.00	19.00	47.00	44.00	37.35	39.14	131.00	58.06	23.69	102.00

*****Angle could not be measured due to the condition of the specimen this had no influence on the regression analysis and was therefore not omitted. #Due to the number of years that some specimens were in the Pretoria Bone collection the age of many is not known, this did not influence the results of the regression analysis.

Table 9.4 *Measurements A, B and C as well as the angle, depth, bizygomatic breadth (BZB), bi-infraorbital foramen breadth (BIOFB), intraorbital breadth (IOB) and least frontal breadth (LFB) for black males.*

Spec_no	Age	A_Left_1	A_Right_1	B_Left_1	B_Right_1	Angle_L_1	Angle_R_1	Depth_L_1	Depth_R_1	C_L_1	C_R_1	BZB_1	BIOFB_1	IOB_1	LFB_1
2608	50	71.65	75.65	14.78	14.79	21.00	17.50	49.00	49.00	40.28	41.00	139.00	63.26	22.70	101.00
2971	70	70.19	72.15	12.35	11.57	15.00	20.00	47.00	44.00	38.75	35.99	129.00	64.84	25.71	96.00
3177	56	71.24	73.07	10.33	11.73	16.00	19.00	44.00	44.00	36.36	37.36	124.00	51.50	23.17	102.00
3688	60	73.42	72.95	13.21	13.51	26.00	20.00	48.00	43.00	36.89	36.42	130.00	53.73	17.99	96.00
4294	72	68.30	67.11	14.88	12.37	25.00	20.00	53.00	48.00	38.10	38.06	134.00	59.68	21.28	95.00
4340	42	73.36	74.78	15.21	14.70	24.00	14.00	45.00	48.00	36.59	38.21	135.00	48.94	21.94	100.00
4382	46	70.38	67.33	11.67	11.50	20.00	16.00	47.00	48.00	36.28	37.41	137.00	53.57	24.07	99.00
4396	65	65.62	69.62	13.69	14.33	23.00	25.00	44.00	67.00	37.07	36.97	129.00	55.71	20.91	90.00
4407	45	70.26	71.44	12.66	13.20	16.00	12.00	46.00	48.00	35.33	34.47	134.00	64.84	25.23	100.00
4414	48	69.26	73.66	14.74	15.21	22.50	17.00	45.00	44.00	36.81	36.13	129.00	60.32	25.73	103.00
4602	60	64.09	67.41	16.24	15.53	27.00	17.50	46.00	47.00	38.08	38.80	130.00	55.68	22.56	100.00
4614	53	67.58	69.29	10.89	11.67	26.00	27.00	48.00	44.00	32.28	31.90	128.00	55.86	20.40	104.00
4681	80	75.54	78.52	15.52	16.99	17.50	15.00	51.00	49.00	40.07	41.50	137.00	64.42	29.69	100.00
4709	65	72.59	72.65	14.11	14.99	20.00	18.00	43.00	39.00	40.27	38.92	132.00	63.37	24.74	104.00
4723	60	76.76	77.72	15.24	14.63	17.50	16.00	49.00	47.00	38.97	37.57	139.00	55.70	26.85	106.00
4799	32	59.47	61.66	12.54	12.66	20.00	24.00	38.00	34.00	33.11	32.88	115.00	47.58	19.85	90.00
4815	65	72.99	72.41	18.40	17.56	25.00	22.00	49.00	48.00	36.43	37.02	139.00	61.17	21.14	104.00
5051	52	72.37	70.46	15.60	14.83	16.00	17.00	50.00	50.00	38.89	38.98	128.00	59.72	22.76	100.00
5091	65	74.80	75.86	12.53	12.47	15.00	13.00	45.00	44.00	34.94	33.69	132.00	58.43	19.28	96.00
5110	65	72.68	75.53	15.27	17.48	11.00	25.00	50.00	48.00	35.87	38.57	133.00	59.80	24.93	100.00
5209	60	68.45	70.05	12.12	13.41	17.00	17.50	42.00	41.00	37.26	38.53	133.00	56.26	21.30	98.00
5293	27	67.68	70.28	13.12	13.78	14.00	23.00	44.00	45.00	36.15	36.27	127.00	54.77	25.22	100.00
5312	70	67.24	67.29	11.56	13.49	20.00	17.00	48.00	50.00	37.18	39.26	131.00	56.72	19.48	96.00
5329	42	73.19	70.97	14.52	14.16	25.00	14.00	47.00	49.00	37.11	35.87	124.00	56.35	23.96	96.00
5359	39	72.71	71.03	14.96	15.47	11.00	22.00	49.00	50.00	36.11	35.90	130.00	57.44	21.90	95.00
5379	70	70.32	70.06	13.80	13.79	18.00	22.00	47.00	47.00	36.54	36.67	130.00	59.35	21.97	99.00
5542	57	72.59	72.06	12.23	14.39	14.00	15.00	47.00	45.00	36.34	37.72	134.00	62.96	24.44	101.00
5740	60	71.29	72.06	14.63	14.81	17.00	22.00	49.00	49.00	36.40	37.25	135.00	56.96	22.61	101.00
5752	52	71.59	72.06	14.31	12.86	25.00	24.00	46.00	45.00	36.66	36.12	130.00	52.23	19.42	100.00
5831	45	70.78	69.57	12.78	12.15	26.00	17.50	47.00	44.00	37.23	37.32	139.00	61.90	26.86	99.00
5931	50	72.70	74.21	13.87	14.52	21.00	21.00	48.00	44.00	39.12	40.18	135.00	61.18	25.69	98.00
6142	43	75.13	75.12	16.49	17.12	14.00	23.00	55.00	53.00	42.81	43.07	140.00	60.50	23.32	99.00
6199	27	73.03	75.56	16.31	16.10	15.00	15.00	45.00	48.00	40.15	41.22	136.00	59.38	25.26	100.00
6400	68	67.19	68.59	13.56	13.13	29.00	21.00	41.50	46.00	34.73	35.34	130.00	55.49	20.22	95.00
6409	70	77.93	81.76	16.59	16.37	21.00	18.00	51.00	44.00	39.99	39.56	140.00	63.16	25.50	104.00
3296#		68.83	71.93	13.01	12.55	15.00	10.00	47.00	40.00	34.65	36.64	127.00	51.69	19.63	98.00
4538#		71.28	75.09	15.09	14.93	18.00	16.00	52.00	49.00	39.23	37.86	135.00	60.95	21.68	100.00
5141†	60	66.89	66.10	11.35	12.20	15.00	22.00	43.00	41.00	33.51	35.11		61.66	25.80	104.00
5500#		69.03	71.69	16.51	16.38	11.00	15.00	49.00	47.00	38.80	39.93	130.00	67.38	24.99	101.00
6405#		72.86	72.68	12.47	12.55	23.00	21.00	46.00	43.00	37.63	36.48	126.00	50.95	20.76	94.00

#Due to the number of years that some specimens were in the Pretoria Bone collection the age of many is not known, this did not influence the results of the regression analysis. †As a result of an anomaly the BZB could not be measured in this case. It was excluded from the initial regression analysis but as it was not significant it was replaced for the final analysis

Table 9.5 *Measurements repeated for determination of intraobserver error taken two weeks after initial measurements. Includes measurement A and B as well as the angle and depth for white females.*

Spec_no	Age	A_Left	A_Right	B_Left	B_Right	Angle_L	Angle_R	Depth_L	Depth_R
4467	54	65.92	65.86	13.42	12.31	21.00	12.00	41.00	42.00
5299	86	64.09	64.40	11.48	12.98	22.00	23.00	45.00	44.00
5373	65	64.12	65.70	13.13	12.43	21.00	16.00	44.00	42.00
5408	76	61.02	65.60	11.53	11.90	25.00	22.00	45.00	43.00
5442		64.74	66.75	11.96	12.54	27.00	16.00	43.00	42.00
5452	84	71.65	72.51	14.39	13.49	29.00	26.00	45.00	46.00
5456	54	65.31	68.42	11.22	10.95	19.00	22.50	41.00	39.00
5488	56	68.82	70.87	10.89	11.62	22.50	19.00	45.00	43.00
5553	60	65.01	65.65	12.41	13.45	16.00	23.00	46.00	42.00
5562	81	65.83	66.68	10.15	10.22	12.00	18.00	45.00	44.00
5575	87	64.56	67.36	12.06	11.95	17.50	19.00	45.00	41.00
5583	79	66.74	67.16	9.64	9.79	23.00	21.00	42.00	44.00
5594	69	65.00	67.42	11.09	10.84	23.00	27.00	42.00	41.00
5607	57	62.07	63.49	7.14	7.29	19.00	20.00	40.00	39.00
5612	69	73.03	71.23	11.05	10.09	23.00	22.00	41.00	44.00
5693	86	66.02	66.73	12.78	14.47	22.00	25.00	46.00	45.00
5716	67	66.49	67.10	12.13	11.07	19.00	17.50	45.00	43.00
5744	89	69.35	70.88	12.43	12.10	20.00	18.00	49.00	46.00
5758	76	67.62	68.02	11.68	12.09	26.00	21.00	44.00	45.00
5763	75	67.47	70.01	15.70	14.46	23.00	27.00	43.00	44.00
5769	74	63.75	64.12	11.53	11.44	21.00	15.00	40.00	42.00
5774	80	70.10	67.83	12.29	13.10	29.00	26.00	43.00	44.00
5806	77	68.72	71.02	13.42	14.14	21.00	22.50	50.00	49.00
5818	50	65.82	66.27	11.27	10.55	21.00	20.00	39.00	38.00
5895	57	63.18	65.05	10.26	10.21	21.00	22.00	46.00	45.00
5918	71	70.69	69.74	11.40	12.49	21.00	21.00	45.00	46.00
6064	48	65.68	65.81	12.55	10.46	19.00	20.00	41.00	41.00
6117	77	69.55	69.44	13.45	13.72	22.00	17.00	49.00	47.00
6208	78	68.35	66.41	13.50	12.86	14.00	17.00	45.00	49.00
6213	79	62.66	64.78	11.56	11.17	18.00	10.00	42.00	43.00
6215	69	63.01	62.88	9.31	8.70	21.00	17.50	41.00	40.00
6227	85	66.84	66.35	12.59	12.82	14.00	16.00	45.00	40.00
6246	77	58.91	60.37	9.35	9.42	26.00	21.00	38.00	38.00
6266	76	63.94	63.14	14.91	12.97	17.00	15.00	42.00	41.00
6293	48	65.40	67.80	11.32	13.90	23.00	20.00	41.00	44.00
6319	64	66.36	68.77	10.50	10.43	26.00	16.00	40.00	39.00
6322	81	62.81	66.66	10.13	11.02	23.00	16.00	41.00	42.00
6340	87	67.75	68.17	13.12	13.90	20.00	17.50	46.00	47.00
6347	56	65.05	64.05	9.98	9.69	13.00	18.00	36.00	39.00
6396	90	68.80	71.18	12.10	11.89	16.00	19.00	43.00	44.00

Table 9.6 *Measurements repeated for determination of intraobserver error taken two weeks after initial measurements. Includes measurement A and B as well as the angle and depth for white males.*

Spec_no	Age	A_Left	A_Right	B_Left	B_Right	Angle_L	Angle_R	Depth_L	Depth_R
3700	77	68.22	70.01	11.46	11.34	22.00	22.00	48.00	50.00
4006	94	68.94	68.44	11.13	11.61	20.00	19.00	46.00	44.00
4194	77	65.48	68.68	14.06	15.44	24.00	17.00	44.00	43.00
4377	58	67.26	67.15	14.42	14.11	24.00	19.00	51.00	48.00
4416	91	68.94	69.53	11.62	10.26	25.00	24.00	42.00	44.00
4481	78	68.01	69.00	16.94	16.68	15.00	10.00	42.00	46.00
4537	59	71.54	68.18	11.35	11.23	26.00	18.00	48.00	49.00
4754	71	71.21	70.09	16.54	16.26	24.00	18.00	48.00	49.00
4818	49	68.96	73.20	11.55	12.78	20.00	17.00	48.00	48.00
5127	78	72.88	73.02	13.95	13.00	20.00	14.00	48.00	44.00
5225	62	70.95	70.32	13.87	13.64	25.00	17.00	42.00	47.00
5325	77	68.89	69.54	12.78	13.43	17.00	16.00	41.00	52.00
5328		74.10	74.69	12.92	11.48	23.00	19.00	46.00	49.00
5387	55	77.20	76.77	13.78	13.69	17.00	15.00	52.00	51.00
5434	80	70.40	71.23	14.01	12.84	25.00	21.00	51.00	49.00
5573	80	57.88	69.30	13.02	13.37	25.00	21.00	46.00	50.00
5592	74	71.06	74.36	12.62	13.83	20.00	20.00	43.00	43.00
5626	51	73.57	71.84	15.96	15.38	21.00	20.00	41.00	42.00
5641	76	63.58	64.64	12.15	12.02	19.00	21.00	42.00	42.00
5650	85	69.46	71.11	15.56	16.02	19.00	20.00	46.00	47.00
5677	73	69.20	71.57	10.25	10.88	30.00	20.00	47.00	49.00
5719		68.06	67.72	12.04	11.67	21.00	16.00	48.00	45.00
5784	83	72.14	73.78	15.53	14.70	19.00	17.00	42.00	42.00
5799	80	71.96	72.65	12.54	12.10	18.00	16.00	52.00	50.00
5811	74	65.27	65.93	11.93	11.34	21.00	14.00	41.00	45.00
5817	63	72.58	75.51	13.71	13.71	17.50	10.00	43.00	50.00
5858	75	72.50	73.61	11.96	12.32	17.00	15.00	47.00	49.00
5909	64	72.29	72.58	9.92	10.82	19.00	10.00	43.00	44.00
5916	77	70.96	71.94	10.89	10.92	23.00	22.50	46.00	46.00
5924	69	72.77	71.34	13.65	13.83	22.50	15.00	51.00	46.00
6008	48	74.74	73.21	14.74	14.98	19.00	21.00	49.00	49.00
6219	67	71.00	72.07	12.69	12.44	22.00	23.00	45.00	45.00
6241	87	72.45	73.47	12.76	13.15	17.50	21.00	49.00	51.00
6288	70	69.07	70.33	12.86	14.76	23.00	16.00	42.00	49.00
6302	79	71.55	71.76	14.24	13.58	22.00	15.00	48.00	50.00
6307	70	74.66	75.05	12.82	13.06	20.00	21.00	45.00	44.00
6341	89	69.02	71.15	12.80	13.28	23.00	15.00	49.00	49.00
6348	61	70.39	69.35	14.50	13.38	29.00	17.50	42.00	44.00
6374	51	69.21	70.05	14.73	15.09	13.00	16.00	48.00	48.00
6385	80	68.13	70.08	12.04	11.80	18.00	21.00	45.00	44.00

Table 9.7 *Measurements repeated for determination of intraobserver error taken two weeks after initial measurements. Includes measurement A and B as well as the angle and depth for black females.*

Spec_no	Age	A_Left	A_Right	B_Left	B_Right	Angle_L	Angle_R	Depth_L	Depth_R
1636	48	68.38	70.26	13.75	12.85	25.00		46.00	
2615	58	69.52	69.21	12.31	12.53	21.00	20.00	44.00	45.00
2900	60	67.95	66.63	11.41	9.80	25.00	25.00	44.00	41.00
3154	40	70.48	70.95	12.09	9.91	23.00	16.00	48.00	47.00
3394		69.68	73.68	14.40	15.74	20.00	16.00	44.00	44.00
3669	65	68.72	71.05	12.30	11.28	16.00	17.50	44.00	43.00
4239	60	68.43	70.45	14.71	14.90	24.00	14.00	44.00	47.00
4436	37	68.58	70.86	14.27	14.71	16.00	11.00	43.00	49.00
4442	35	63.72	61.72	11.30	11.48	19.00	15.00	48.00	42.00
4448	38	65.04	65.31	11.90	12.31	24.00	20.00	38.00	39.00
4486	48	67.52	69.77	13.33	14.12	21.00	20.00	43.00	44.00
4516	42	69.77	70.49	15.80	17.02	20.00	15.00	45.00	47.00
4521	50	65.69	67.36	14.09	14.60	20.00	17.00	48.00	44.00
4529	60	74.37	74.70	13.19	12.99	22.00	20.00	43.00	43.00
4598	32	63.46	69.55	13.58	13.91	20.00	15.00	48.00	49.00
5033	70	68.52	67.65	14.40	14.08	20.00	18.00	48.00	47.00
5079	45	60.79	62.79	14.91	15.05	29.00	30.00	39.00	40.00
5150	31	64.24	68.13	14.54	15.69	20.00	16.00	42.00	40.00
5156	41	79.65	82.20	16.18	15.69	22.50	21.00	49.00	50.00
5292	46	63.26	64.86	13.07	13.50	17.50	19.00	42.00	39.00
5319	70	63.36	63.81	13.06	12.74	27.50	27.50	43.00	42.00
5342	57	65.15	65.53	11.97	10.27	20.00	17.50	45.00	49.00
5390	65	64.42	67.94	11.29	11.43	26.00	17.50	45.00	48.00
5635	50	63.77	66.06	14.69	12.78	28.00	25.00	41.00	43.00
5692	44	68.57	67.97	10.41	9.69	24.00	20.00	38.00	45.00
5705	65	70.16	70.61	13.26	11.48	12.00	23.00	44.00	38.00
5892	26	66.97	70.88	13.72	13.29	21.00	13.00	45.00	47.00
6094	33	64.51	67.60	12.72	12.48	24.00	16.00	42.00	41.00
6139	38	69.02	70.00	13.67	13.44	28.00	20.00	42.00	48.00
6144	50	68.11	69.05	12.05	11.91	13.00	24.00	42.00	52.00
6156	65	67.10	68.98	10.99	10.30	25.00	26.00	42.00	42.00
6157	30	63.71	65.39	14.53	13.94	19.00	17.00	37.00	39.00
6172	53	68.89	70.91	15.65	16.04	21.00	21.00	40.00	40.00
6192	22	66.19	71.39	12.32	12.40	22.00	21.00	49.00	44.00
6237	56	65.53	66.19	14.34	13.33	19.00	12.00	43.00	43.00
6290	24	67.50	67.94	12.04	12.14	22.00	13.00	39.00	42.00
6315	64	71.23	73.31	17.47	16.27	25.00	17.00	44.00	49.00
6328	47	73.09	71.89	14.46	14.68	24.00	15.00	40.00	43.00
6370	60	65.56	67.16	12.50	13.20	19.00	15.00	44.00	43.00
6388	47	69.58	70.97	13.67	14.33	20.00	15.00	49.00	50.00

Table 9.8 *Measurements repeated for determination of intraobserver error taken two weeks after initial measurements. Includes measurement A and B as well as the angle and depth for black males.*

Spec_no	Age	A_Left	A_Right	B_Left	B_Right	Angle_L	Angle_R	Depth_L	Depth_R
2608	50	71.03	77.60	14.57	15.11	14.00	15.00	49.00	47.00
2971	70	71.33	72.46	13.24	12.47	25.00	15.00	47.00	44.00
3177	56	69.46	71.92	11.21	12.38	16.00	15.00	44.00	42.00
3296		67.85	72.08	13.37	12.54	22.00	25.00	44.00	46.00
3688	60	71.75	72.52	13.35	13.95	24.00	20.00	42.00	48.00
4294	72	66.95	66.75	15.87	13.52	20.00	17.00	57.00	48.00
4340	42	73.32	74.29	14.98	15.11	20.00	12.00	42.00	48.00
4382	46	67.79	66.85	12.40	12.09	14.00	12.00	48.00	46.00
4396	65	64.68	69.36	14.93	15.42	18.00	15.00	45.00	44.00
4407	45	68.33	70.28	13.59	14.16	20.00	8.00	48.00	47.00
4414	48	67.82	72.66	15.52	15.54	12.00	10.00	45.00	42.00
4538		69.92	74.86	15.08	15.60	22.00	17.50	51.00	46.00
4602	60	62.97	64.33	15.94	15.74	17.00	16.00	43.00	44.00
4614	53	66.51	69.30	11.38	11.99	23.00	12.00	47.00	42.00
4681	80	74.40	78.60	16.32	16.98	18.00	14.00	49.00	49.00
4709	65	72.54	72.91	15.03	15.50	24.00	19.00	41.00	40.00
4723	60	76.02	76.37	15.84	15.28	19.00	12.00	52.00	49.00
4799	32	56.69	62.54	13.09	14.73	21.00	21.00	38.00	35.00
4815	65	71.49	69.94	18.10	17.45	20.00	17.50	49.00	45.00
5051	52	70.59	70.96	17.09	16.40	17.00	16.00	46.00	50.00
5091	65	74.90	76.56	13.18	13.21	17.50	16.00	45.00	43.00
5110	65	71.62	74.88	16.45	18.29	21.00	20.00	41.00	45.00
5141	60	66.77	67.81	11.47	12.56	17.50	17.00	42.00	42.00
5209	60	67.30	71.39	12.22	13.17	26.00	11.00	42.00	41.00
5293	27	66.65	71.61	14.02	14.10	18.00	21.00	45.00	45.00
5312	70	65.88	69.01	14.18	15.06	19.00	14.00	50.00	48.00
5329	42	71.61	73.19	14.80	14.71	25.00	15.00	48.00	44.00
5359	39	72.17	72.17	15.28	15.47	25.00	21.00	50.00	49.00
5379	70	70.09	71.99	13.94	14.32	21.00	20.00	46.00	48.00
5500		66.76	71.65	17.60	17.65	17.00	18.00	49.00	48.00
5542	57	72.24	71.82	13.60	14.73	20.00	17.00	47.00	48.00
5740	60	69.98	72.74	14.31	14.73	22.00	20.00	49.00	49.00
5752	52	70.62	71.13	14.60	13.08	24.00	25.00	48.00	46.00
5831	45	69.44	67.54	13.04	13.02	20.00	10.00	48.00	41.00
5931	50	71.01	72.70	14.24	15.12	22.00	11.00	46.00	43.00
6142	43	74.64	74.77	16.96	18.08	16.00	17.00	53.00	52.00
6199	27	73.35	75.90	16.85	17.09	22.00	11.00	48.00	46.00
6400	68	64.88	67.88	13.35	12.91	31.00	21.00	41.00	42.00
6405		71.56	72.09	12.74	12.60	16.00	12.00	45.00	42.00
6409	70	76.44	80.91	16.52	17.20	20.00	11.00	51.00	44.00

Table 9.9 *Measurements A and B on the left and the indices calculated for white females on the left (YL) and on the right (YR).*

Spec_no	A_Left	A_Right	B_Left	B_Right	YL=B/A*100	YR=B/A*100
4467	67.04	65.75	13.24	11.76	19.75	17.89
5299	63.06	61.93	11.23	12.44	17.81	20.09
5373	64.93	64.50	13.93	12.17	21.45	18.87
5408	61.73	64.72	11.76	12.04	19.05	18.60
5452	72.83	72.53	14.39	13.75	19.76	18.96
5456	66.83	67.63	10.66	10.53	15.95	15.57
5488	68.94	70.68	10.83	11.62	15.71	16.44
5553	65.82	66.49	12.45	12.94	18.92	19.46
5575	64.94	68.27	11.88	11.74	18.29	17.20
5583	66.81	66.52	9.77	9.91	14.62	14.90
5594	65.54	68.30	11.00	10.71	16.78	15.68
5607	61.60	63.14	7.19	7.53	11.67	11.93
5612	74.02	70.95	10.38	9.90	14.02	13.95
5693	66.27	66.68	12.67	15.25	19.12	22.87
5716	66.52	66.74	11.13	10.38	16.73	15.55
5744	71.27	72.11	12.21	11.92	17.13	16.53
5758	67.99	67.84	11.33	11.98	16.66	17.66
5763	67.02	69.97	14.83	13.48	22.13	19.27
5769	63.20	66.00	11.63	10.92	18.40	16.55
5774	70.87	68.20	11.98	12.46	16.90	18.27
5806	68.89	71.26	13.08	13.90	18.99	19.51
5818	66.83	67.58	11.20	10.83	16.76	16.03
5895	64.29	65.72	9.59	9.97	14.92	15.17
5918	69.98	67.66	11.36	12.72	16.23	18.80
6064	65.50	63.80	11.32	10.09	17.28	15.82
6117	70.32	70.03	12.99	13.20	18.47	18.85
6208	68.10	65.15	13.63	12.63	20.01	19.39
6213	63.67	65.50	10.94	11.07	17.18	16.90
6215	64.45	63.81	9.19	8.67	14.26	13.59
6227	66.02	66.07	11.54	12.24	17.48	18.53
6246	59.95	60.21	9.02	9.54	15.05	15.84
6266	64.42	64.02	14.49	12.89	22.49	20.13
6293	65.58	67.19	11.19	13.54	17.06	20.15
6319	67.18	68.31	10.50	10.38	15.63	15.20
6322	62.95	66.05	10.03	10.92	15.93	16.53
6340	67.15	68.04	12.60	12.71	18.76	18.68
6347	64.86	62.20	10.16	9.76	15.66	15.69
6396	67.66	69.34	10.52	10.77	15.55	15.53
					17.33	**17.28**

Table 9.10 *Measurements A and B on the left and the indices calculated for white males on the left (YL) and on the right (YR).*

Spec_no	A_Left	A_Right	B_Left	B_Right	YL=B/A*100	YR=B/A*100
3700	70.09	69.37	10.92	10.84	15.58	15.63
4006	69.98	68.14	10.78	11.43	15.40	16.77
4194	67.31	67.28	13.89	15.34	20.64	22.80
4377	67.49	67.62	13.84	13.55	20.51	20.04
4416	68.69	69.52	10.99	10.16	16.00	14.61
4481	68.86	69.31	16.89	15.56	24.53	22.45
4537	72.72	69.81	10.82	11.05	14.88	15.83
4754	71.64	69.96	15.11	15.98	21.09	22.84
4818	70.17	73.21	11.42	12.46	16.27	17.02
5127	72.73	73.33	13.43	12.33	18.47	16.81
5225	71.09	69.39	12.93	12.81	18.19	18.46
5325	70.91	68.58	12.92	13.49	18.22	19.67
5387	77.57	76.18	13.82	13.91	17.82	18.26
5434	70.17	70.32	13.26	12.48	18.90	17.75
5573	68.71	68.47	12.71	13.04	18.50	19.04
5592	71.46	74.96	12.28	13.22	17.18	17.64
5626	74.11	73.43	15.73	15.02	21.23	20.45
5641	64.09	63.81	12.09	12.26	18.86	19.21
5650	70.28	70.93	14.55	15.14	20.70	21.34
5677	69.50	71.13	10.33	10.37	14.86	14.58
5784	73.17	75.02	14.60	14.37	19.95	19.15
5799	71.67	71.74	12.24	11.84	17.08	16.50
5811	65.42	66.76	11.08	11.28	16.94	16.90
5817	73.63	75.94	13.69	13.14	18.59	17.30
5858	74.16	73.36	11.46	11.75	15.45	16.02
5909	73.52	72.90	10.22	10.67	13.90	14.64
5916	71.99	72.06	10.37	10.43	14.40	14.47
5924	75.54	72.87	13.59	13.68	17.99	18.77
6008	73.57	73.18	13.97	14.25	18.99	19.47
6219	70.33	71.64	11.92	12.37	16.95	17.27
6241	72.44	70.69	11.36	12.41	15.68	17.56
6288	71.19	70.74	12.21	13.66	17.15	19.31
6302	70.37	71.36	13.45	12.53	19.11	17.56
6307	73.81	72.86	12.34	12.11	16.72	16.62
6341	69.61	71.23	12.26	12.56	17.61	17.63
6348	70.79	68.16	14.02	13.45	19.81	19.73
6374	68.45	69.18	14.29	14.84	20.88	21.45
6385	69.72	69.67	11.48	11.48	16.47	16.48
5562	65.84	65.42	10.28	10.04	15.61	15.35
					17.87	**18.04**

Table 9.11 *Measurements A and B on the left and the indices calculated for black females on the left (YL) and on the right (YR).*

Spec_no	A_Left	A_Right	B_Left	B_Right	YL=B/A*100	YR=B/A*100
2615	70.27	68.42	11.13	11.42	15.84	16.69
2900	68.98	68.16	11.20	9.74	16.24	14.29
3154	70.49	70.78	10.30	9.47	14.61	13.38
3669	69.46	70.83	11.30	10.78	16.27	15.22
4239	70.68	71.67	15.90	15.69	22.50	21.89
4436	69.97	70.81	13.93	14.00	19.91	19.77
4442	63.44	63.97	11.03	11.08	17.39	17.32
4448	65.33	66.81	11.57	11.64	17.71	17.42
4486	68.92	69.91	12.86	13.37	18.66	19.12
4516	71.10	71.03	16.41	16.79	23.08	23.64
4521	66.67	68.75	13.52	13.97	20.28	20.32
4529	74.76	74.78	12.56	12.94	16.80	17.30
4598	63.91	71.44	11.82	12.28	18.49	17.19
5033	68.85	67.63	13.87	14.10	20.15	20.85
5079	61.84	62.06	14.18	13.98	22.93	22.53
5150	65.87	67.30	14.77	15.46	22.42	22.97
5156	79.74	81.86	15.71	15.27	19.70	18.65
5292	63.01	64.90	13.11	13.01	20.81	20.05
5319	64.58	63.85	12.74	12.43	19.73	19.47
5342	65.32	65.87	11.00	9.89	16.84	15.01
5390	64.77	67.00	10.79	11.28	16.66	16.84
5635	64.79	65.51	28.00	18.00	43.22	27.48
5692	69.74	68.69	10.44	9.68	14.97	14.09
5705	69.15	70.28	12.17	10.82	17.60	15.40
5892	68.63	70.30	12.33	13.11	17.97	18.65
6094	66.58	69.11	12.32	12.07	18.50	17.46
6139	69.78	69.08	13.22	13.04	18.95	18.88
6144	67.33	66.64	11.97	11.48	17.78	17.23
6156	68.38	67.26	11.13	10.70	16.28	15.91
6157	64.46	64.58	14.14	13.90	21.94	21.52
6172	67.72	68.72	16.64	16.35	24.57	23.79
6192	68.33	72.38	11.76	12.12	17.21	16.74
6237	67.39	66.27	13.75	13.07	20.40	19.72
6290	65.52	67.18	11.64	11.00	17.77	16.37
6315	71.73	73.17	17.23	15.65	24.02	21.39
6328	74.19	72.99	14.01	14.25	18.88	19.52
6370	66.82	67.65	11.86	12.60	17.75	18.63
6388	67.40	79.17	13.66	13.40	20.27	16.93
					19.61	**18.67**

Table 9.12 *Measurements A and B on the left and the indices calculated for black males on the left (YL) and on the right (YR).*

Spec_no	A_Left	A_Right	B_Left	B_Right	YL=B/A*100	YR=B/A*100
2608	71.65	75.65	14.78	14.79	20.63	19.55
2971	70.19	72.15	12.35	11.57	17.60	16.04
3177	71.24	73.07	10.33	11.73	14.50	16.05
3688	73.42	72.95	13.21	13.51	17.99	18.52
4294	68.30	67.11	14.88	12.37	21.79	18.43
4340	73.36	74.78	15.21	14.70	20.73	19.66
4382	70.38	67.33	11.67	11.50	16.58	17.08
4396	65.62	69.62	13.69	14.33	20.86	20.58
4407	70.26	71.44	12.66	13.20	18.02	18.48
4414	69.26	73.66	14.74	15.21	21.28	20.65
4602	64.09	67.41	16.24	15.53	25.34	23.04
4614	67.58	69.29	10.89	11.67	16.11	16.84
4681	75.54	78.52	15.52	16.99	20.55	21.64
4709	72.59	72.65	14.11	14.99	19.44	20.63
4723	76.76	77.72	15.24	14.63	19.85	18.82
4799	59.47	61.66	12.54	12.66	21.09	20.53
4815	72.99	72.41	18.40	17.56	25.21	24.25
5051	72.37	70.46	15.60	14.83	21.56	21.05
5091	74.80	75.86	12.53	12.47	16.75	16.44
5110	72.68	75.53	15.27	17.48	21.01	23.14
5209	68.45	70.05	12.12	13.41	17.71	19.14
5293	67.68	70.28	13.12	13.78	19.39	19.61
5312	67.24	67.29	11.56	13.49	17.19	20.05
5329	73.19	70.97	14.52	14.16	19.84	19.95
5359	72.71	71.03	14.96	15.47	20.57	21.78
5379	70.32	70.06	13.80	13.79	19.62	19.68
5542	72.59	72.06	12.23	14.39	16.85	19.97
5740	71.29	72.06	14.63	14.81	20.52	20.55
5752	71.59	72.06	14.31	12.86	19.99	17.85
5831	70.78	69.57	12.78	12.15	18.06	17.46
5931	72.70	74.21	13.87	14.52	19.08	19.57
6142	75.13	75.12	16.49	17.12	21.95	22.79
6199	73.03	75.56	16.31	16.10	22.33	21.31
6400	67.19	68.59	13.56	13.13	20.18	19.14
6409	77.93	81.76	16.59	16.37	21.29	20.02
					19.76	**19.72**

Table 9.13 *Measurements A and B on the left and the indices calculated for blacks on the left (YL) and on the right (YR) for specimens 1636-5141.*

Spec_no	A_Left	A_Right	B_Left	B_Right	YL=B/A*100	YR=B/A*100
1636	68.86	70.87	14.07	13.39	20.43	18.89
2608	71.65	75.65	14.78	14.79	20.63	19.55
2615	70.27	68.42	11.13	11.42	15.84	16.69
2900	68.98	68.16	11.20	9.74	16.24	14.29
2971	70.19	72.15	12.35	11.57	17.60	16.04
3154	70.49	70.78	10.30	9.47	14.61	13.38
3177	71.24	73.07	10.33	11.73	14.50	16.05
3296	68.83	71.93	13.01	12.55	18.90	17.45
3394	70.15	75.05	12.97	13.85	18.49	18.45
3669	69.46	70.83	11.30	10.78	16.27	15.22
3688	73.42	72.95	13.21	13.51	17.99	18.52
4239	70.68	71.67	15.90	15.69	22.50	21.89
4294	68.30	67.11	14.88	12.37	21.79	18.43
4340	73.36	74.78	15.21	14.70	20.73	19.66
4382	70.38	67.33	11.67	11.50	16.58	17.08
4396	65.62	69.62	13.69	14.33	20.86	20.58
4407	70.26	71.44	12.66	13.20	18.02	18.48
4414	69.26	73.66	14.74	15.21	21.28	20.65
4436	69.97	70.81	13.93	14.00	19.91	19.77
4442	63.44	63.97	11.03	11.08	17.39	17.32
4448	65.33	66.81	11.57	11.64	17.71	17.42
4486	68.92	69.91	12.86	13.37	18.66	19.12
4516	71.10	71.03	16.41	16.79	23.08	23.64
4521	66.67	68.75	13.52	13.97	20.28	20.32
4529	74.76	74.78	12.56	12.94	16.80	17.30
4538	71.28	75.09	15.09	14.93	21.17	19.88
4598	63.91	71.44	11.82	12.28	18.49	17.19
4602	64.09	67.41	16.24	15.53	25.34	23.04
4614	67.58	69.29	10.89	11.67	16.11	16.84
4681	75.54	78.52	15.52	16.99	20.55	21.64
4709	72.59	72.65	14.11	14.99	19.44	20.63
4723	76.76	77.72	15.24	14.63	19.85	18.82
4799	59.47	61.66	12.54	12.66	21.09	20.53
4815	72.99	72.41	18.40	17.56	25.21	24.25
5033	68.85	67.63	13.87	14.10	20.15	20.85
5051	72.37	70.46	15.60	14.83	21.56	21.05
5079	61.84	62.06	14.18	13.98	22.93	22.53
5091	74.80	75.86	12.53	12.47	16.75	16.44
5110	72.68	75.53	15.27	17.48	21.01	23.14
5141	66.89	66.10	11.35	12.20	16.97	18.46

Table 9.14 *Measurements A and B on the left and the indices calculated for blacks on the left (YL) and on the right (YR) for specimen numbers 5150-6409.*

Spec_no	A_Left	A_Right	B_Left	B_Right	YL=B/A*100	YR=B/A*100
5150	65.87	67.30	14.77	15.46	22.42	22.97
5156	79.74	81.86	15.71	15.27	19.70	18.65
5209	68.45	70.05	12.12	13.41	17.71	19.14
5292	63.01	64.90	13.11	13.01	20.81	20.05
5293	67.68	70.28	13.12	13.78	19.39	19.61
5312	67.24	67.29	11.56	13.49	17.19	20.05
5319	64.58	63.85	12.74	12.43	19.73	19.47
5329	73.19	70.97	14.52	14.16	19.84	19.95
5342	65.32	65.87	11.00	9.89	16.84	15.01
5359	72.71	71.03	14.96	15.47	20.57	21.78
5379	70.32	70.06	13.80	13.79	19.62	19.68
5390	64.77	67.00	10.79	11.28	16.66	16.84
5500	69.03	71.69	16.51	16.38	23.92	22.85
5542	72.59	72.06	12.23	14.39	16.85	19.97
5635	64.79	65.51	28.00	18.00	43.22	27.48
5692	69.74	68.69	10.44	9.68	14.97	14.09
5705	69.15	70.28	12.17	10.82	17.60	15.40
5740	71.29	72.06	14.63	14.81	20.52	20.55
5752	71.59	72.06	14.31	12.86	19.99	17.85
5831	70.78	69.57	12.78	12.15	18.06	17.46
5892	68.63	70.30	12.33	13.11	17.97	18.65
5931	72.70	74.21	13.87	14.52	19.08	19.57
6094	66.58	69.11	12.32	12.07	18.50	17.46
6139	69.78	69.08	13.22	13.04	18.95	18.88
6142	75.13	75.12	16.49	17.12	21.95	22.79
6144	67.33	66.64	11.97	11.48	17.78	17.23
6156	68.38	67.26	11.13	10.70	16.28	15.91
6157	64.46	64.58	14.14	13.90	21.94	21.52
6172	67.72	68.72	16.64	16.35	24.57	23.79
6192	68.33	72.38	11.76	12.12	17.21	16.74
6199	73.03	75.56	16.31	16.10	22.33	21.31
6237	67.39	66.27	13.75	13.07	20.40	19.72
6290	65.52	67.18	11.64	11.00	17.77	16.37
6315	71.73	73.17	17.23	15.65	24.02	21.39
6328	74.19	72.99	14.01	14.25	18.88	19.52
6370	66.82	67.65	11.86	12.60	17.75	18.63
6388	67.40	79.17	13.66	13.40	20.27	16.93
6400	67.19	68.59	13.56	13.13	20.18	19.14
6405	72.86	72.68	12.47	12.55	17.12	17.27
6409	77.93	81.76	16.59	16.37	21.29	20.02

Table 9.15 *Measurements A and B on the left and the indices calculated for whites on the left (YL) and on the right (YR) for specimen numbers 3700-5744.*

Spec_no	A_Left	A_Right	B_Left	B_Right	YL=B/A*100	YR=B/A*100
3700	70.09	69.37	10.92	10.84	15.58	15.63
4006	69.98	68.14	10.78	11.43	15.40	16.77
4194	67.31	67.28	13.89	15.34	20.64	22.80
4377	67.49	67.62	13.84	13.55	20.51	20.04
4416	68.69	69.52	10.99	10.16	16.00	14.61
4467	67.04	65.75	13.24	11.76	19.75	17.89
4481	68.86	69.31	16.89	15.56	24.53	22.45
4537	72.72	69.81	10.82	11.05	14.88	15.83
4754	71.64	69.96	15.11	15.98	21.09	22.84
4818	70.17	73.21	11.42	12.46	16.27	17.02
5127	72.73	73.33	13.43	12.33	18.47	16.81
5225	71.09	69.39	12.93	12.81	18.19	18.46
5299	63.06	61.93	11.23	12.44	17.81	20.09
5325	70.91	68.58	12.92	13.49	18.22	19.67
5328	75.79	73.83	12.99	11.68	17.14	15.82
5373	64.93	64.50	13.93	12.17	21.45	18.87
5387	77.57	76.18	13.82	13.91	17.82	18.26
5408	61.73	64.72	11.76	12.04	19.05	18.60
5434	70.17	70.32	13.26	12.48	18.90	17.75
5442	64.88	66.52	11.98	12.43	18.46	18.69
5452	72.83	72.53	14.39	13.75	19.76	18.96
5456	66.83	67.63	10.66	10.53	15.95	15.57
5488	68.94	70.68	10.83	11.62	15.71	16.44
5553	65.82	66.49	12.45	12.94	18.92	19.46
5562	65.84	65.42	10.28	10.04	15.61	15.35
5573	68.71	68.47	12.71	13.04	18.50	19.04
5575	64.94	68.27	11.88	11.74	18.29	17.20
5583	66.81	66.52	9.77	9.91	14.62	14.90
5592	71.46	74.96	12.28	13.22	17.18	17.64
5594	65.54	68.30	11.00	10.71	16.78	15.68
5607	61.60	63.14	7.19	7.53	11.67	11.93
5612	74.02	70.95	10.38	9.90	14.02	13.95
5626	74.11	73.43	15.73	15.02	21.23	20.45
5641	64.09	63.81	12.09	12.26	18.86	19.21
5650	70.28	70.93	14.55	15.14	20.70	21.34
5677	69.50	71.13	10.33	10.37	14.86	14.58
5693	66.27	66.68	12.67	15.25	19.12	22.87
5716	66.52	66.74	11.13	10.38	16.73	15.55
5719	69.72	69.10	11.93	11.60	17.11	16.79
5744	71.27	72.11	12.21	11.92	17.13	16.53

Table 9.16 *Measurements A and B on the left and the indices calculated for whites on the left (YL) and on the right (YR) for specimens 5758-6396.*

Spec_no	A_Left	A_Right	B_Left	B_Right	YL=B/A*100	YR=B/A*100
5758	67.99	67.84	11.33	11.98	16.66	17.66
5763	67.02	69.97	14.83	13.48	22.13	19.27
5769	63.20	66.00	11.63	10.92	18.40	16.55
5774	70.87	68.20	11.98	12.46	16.90	18.27
5784	73.17	75.02	14.60	14.37	19.95	19.15
5799	71.67	71.74	12.24	11.84	17.08	16.50
5806	68.89	71.26	13.08	13.90	18.99	19.51
5811	65.42	66.76	11.08	11.28	16.94	16.90
5817	73.63	75.94	13.69	13.14	18.59	17.30
5818	66.83	67.58	11.20	10.83	16.76	16.03
5858	74.16	73.36	11.46	11.75	15.45	16.02
5895	64.29	65.72	9.59	9.97	14.92	15.17
5909	73.52	72.90	10.22	10.67	13.90	14.64
5916	71.99	72.06	10.37	10.43	14.40	14.47
5918	69.98	67.66	11.36	12.72	16.23	18.80
5924	75.54	72.87	13.59	13.68	17.99	18.77
6008	73.57	73.18	13.97	14.25	18.99	19.47
6064	65.50	63.80	11.32	10.09	17.28	15.82
6117	70.32	70.03	12.99	13.20	18.47	18.85
6208	68.10	65.15	13.63	12.63	20.01	19.39
6213	63.67	65.50	10.94	11.07	17.18	16.90
6215	64.45	63.81	9.19	8.67	14.26	13.59
6219	70.33	71.64	11.92	12.37	16.95	17.27
6227	66.02	66.07	11.54	12.24	17.48	18.53
6241	72.44	70.69	11.36	12.41	15.68	17.56
6246	59.95	60.21	9.02	9.54	15.05	15.84
6266	64.42	64.02	14.49	12.89	22.49	20.13
6288	71.19	70.74	12.21	13.66	17.15	19.31
6293	65.58	67.19	11.19	13.54	17.06	20.15
6302	70.37	71.36	13.45	12.53	19.11	17.56
6307	73.81	72.86	12.34	12.11	16.72	16.62
6319	67.18	68.31	10.50	10.38	15.63	15.20
6322	62.95	66.05	10.03	10.92	15.93	16.53
6340	67.15	68.04	12.60	12.71	18.76	18.68
6341	69.61	71.23	12.26	12.56	17.61	17.63
6347	64.86	62.20	10.16	9.76	15.66	15.69
6348	70.79	68.16	14.02	13.45	19.81	19.73
6374	68.45	69.18	14.29	14.84	20.88	21.45
6385	69.72	69.67	11.48	11.48	16.47	16.48
6396	67.66	69.34	10.52	10.77	15.55	15.53

Table 9.17 *Measurements A and B on the left and the indices calculated for females on the left (YL) and on the right (YR) for specimens 1636-5692.*

Spec_no	A_Left	A_Right	B_Left	B_Right	YL=B/A*100	YR=B/A*100
1636	68.86	70.87	14.07	13.39	20.43	18.89
2615	70.27	68.42	11.13	11.42	15.84	16.69
2900	68.98	68.16	11.20	9.74	16.24	14.29
3154	70.49	70.78	10.30	9.47	14.61	13.38
3394	70.15	75.05	12.97	13.85	18.49	18.45
3669	69.46	70.83	11.30	10.78	16.27	15.22
4239	70.68	71.67	15.90	15.69	22.50	21.89
4436	69.97	70.81	13.93	14.00	19.91	19.77
4442	63.44	63.97	11.03	11.08	17.39	17.32
4448	65.33	66.81	11.57	11.64	17.71	17.42
4467	67.04	65.75	13.24	11.76	19.75	17.89
4486	68.92	69.91	12.86	13.37	18.66	19.12
4516	71.10	71.03	16.41	16.79	23.08	23.64
4521	66.67	68.75	13.52	13.97	20.28	20.32
4529	74.76	74.78	12.56	12.94	16.80	17.30
4598	63.91	71.44	11.82	12.28	18.49	17.19
5033	68.85	67.63	13.87	14.10	20.15	20.85
5079	61.84	62.06	14.18	13.98	22.93	22.53
5150	65.87	67.30	14.77	15.46	22.42	22.97
5156	79.74	81.86	15.71	15.27	19.70	18.65
5292	63.01	64.90	13.11	13.01	20.81	20.05
5299	63.06	61.93	11.23	12.44	17.81	20.09
5319	64.58	63.85	12.74	12.43	19.73	19.47
5342	65.32	65.87	11.00	9.89	16.84	15.01
5373	64.93	64.50	13.93	12.17	21.45	18.87
5390	64.77	67.00	10.79	11.28	16.66	16.84
5408	61.73	64.72	11.76	12.04	19.05	18.60
5442	64.88	66.52	11.98	12.43	18.46	18.69
5452	72.83	72.53	14.39	13.75	19.76	18.96
5456	66.83	67.63	10.66	10.53	15.95	15.57
5488	68.94	70.68	10.83	11.62	15.71	16.44
5553	65.82	66.49	12.45	12.94	18.92	19.46
5562	65.84	65.42	10.28	10.04	15.61	15.35
5575	64.94	68.27	11.88	11.74	18.29	17.20
5583	66.81	66.52	9.77	9.91	14.62	14.90
5594	65.54	68.30	11.00	10.71	16.78	15.68
5607	61.60	63.14	7.19	7.53	11.67	11.93
5612	74.02	70.95	10.38	9.90	14.02	13.95
5635	64.79	65.51	28.00	18.00	43.22	27.48
5692	69.74	68.69	10.44	9.68	14.97	14.09

Table 9.18 *Measurements A and B on the left and the indices calculated for females on the left (YL) and on the right (YR) for specimens 5693-6396.*

Spec_no	A_Left	A_Right	B_Left	B_Right	YL=B/A*100	YR=B/A*100
5693	66.27	66.68	12.67	15.25	19.12	22.87
5705	69.15	70.28	12.17	10.82	17.60	15.40
5716	66.52	66.74	11.13	10.38	16.73	15.55
5744	71.27	72.11	12.21	11.92	17.13	16.53
5758	67.99	67.84	11.33	11.98	16.66	17.66
5763	67.02	69.97	14.83	13.48	22.13	19.27
5769	63.20	66.00	11.63	10.92	18.40	16.55
5774	70.87	68.20	11.98	12.46	16.90	18.27
5806	68.89	71.26	13.08	13.90	18.99	19.51
5818	66.83	67.58	11.20	10.83	16.76	16.03
5892	68.63	70.30	12.33	13.11	17.97	18.65
5895	64.29	65.72	9.59	9.97	14.92	15.17
5918	69.98	67.66	11.36	12.72	16.23	18.80
6064	65.50	63.80	11.32	10.09	17.28	15.82
6094	66.58	69.11	12.32	12.07	18.50	17.46
6117	70.32	70.03	12.99	13.20	18.47	18.85
6139	69.78	69.08	13.22	13.04	18.95	18.88
6144	67.33	66.64	11.97	11.48	17.78	17.23
6156	68.38	67.26	11.13	10.70	16.28	15.91
6157	64.46	64.58	14.14	13.90	21.94	21.52
6172	67.72	68.72	16.64	16.35	24.57	23.79
6192	68.33	72.38	11.76	12.12	17.21	16.74
6208	68.10	65.15	13.63	12.63	20.01	19.39
6213	63.67	65.50	10.94	11.07	17.18	16.90
6215	64.45	63.81	9.19	8.67	14.26	13.59
6227	66.02	66.07	11.54	12.24	17.48	18.53
6237	67.39	66.27	13.75	13.07	20.40	19.72
6246	59.95	60.21	9.02	9.54	15.05	15.84
6266	64.42	64.02	14.49	12.89	22.49	20.13
6290	65.52	67.18	11.64	11.00	17.77	16.37
6293	65.58	67.19	11.19	13.54	17.06	20.15
6315	71.73	73.17	17.23	15.65	24.02	21.39
6319	67.18	68.31	10.50	10.38	15.63	15.20
6322	62.95	66.05	10.03	10.92	15.93	16.53
6328	74.19	72.99	14.01	14.25	18.88	19.52
6340	67.15	68.04	12.60	12.71	18.76	18.68
6347	64.86	62.20	10.16	9.76	15.66	15.69
6370	66.82	67.65	11.86	12.60	17.75	18.63
6388	67.40	79.17	13.66	13.40	20.27	16.93
6396	67.66	69.34	10.52	10.77	15.55	15.53

Table 9.19 *Measurements A and B on the left and the indices calculated for males on the left (YL) and on the right (YR) for specimens 2608-5329.*

Spec_no	A_Left	A_Right	B_Left	B_Right	YL=B/A*100	YR=B/A*100
2608	71.65	75.65	14.78	14.79	20.63	19.55
2971	70.19	72.15	12.35	11.57	17.60	16.04
3177	71.24	73.07	10.33	11.73	14.50	16.05
3296	68.83	71.93	13.01	12.55	18.90	17.45
3688	73.42	72.95	13.21	13.51	17.99	18.52
3700	70.09	69.37	10.92	10.84	15.58	15.63
4006	69.98	68.14	10.78	11.43	15.40	16.77
4194	67.31	67.28	13.89	15.34	20.64	22.80
4294	68.30	67.11	14.88	12.37	21.79	18.43
4340	73.36	74.78	15.21	14.70	20.73	19.66
4377	67.49	67.62	13.84	13.55	20.51	20.04
4382	70.38	67.33	11.67	11.50	16.58	17.08
4396	65.62	69.62	13.69	14.33	20.86	20.58
4407	70.26	71.44	12.66	13.20	18.02	18.48
4414	69.26	73.66	14.74	15.21	21.28	20.65
4416	68.69	69.52	10.99	10.16	16.00	14.61
4481	68.86	69.31	16.89	15.56	24.53	22.45
4537	72.72	69.81	10.82	11.05	14.88	15.83
4538	71.28	75.09	15.09	14.93	21.17	19.88
4602	64.09	67.41	16.24	15.53	25.34	23.04
4614	67.58	69.29	10.89	11.67	16.11	16.84
4681	75.54	78.52	15.52	16.99	20.55	21.64
4709	72.59	72.65	14.11	14.99	19.44	20.63
4723	76.76	77.72	15.24	14.63	19.85	18.82
4754	71.64	69.96	15.11	15.98	21.09	22.84
4799	59.47	61.66	12.54	12.66	21.09	20.53
4815	72.99	72.41	18.40	17.56	25.21	24.25
4818	70.17	73.21	11.42	12.46	16.27	17.02
5051	72.37	70.46	15.60	14.83	21.56	21.05
5091	74.80	75.86	12.53	12.47	16.75	16.44
5110	72.68	75.53	15.27	17.48	21.01	23.14
5127	72.73	73.33	13.43	12.33	18.47	16.81
5141	66.89	66.10	11.35	12.20	16.97	18.46
5209	68.45	70.05	12.12	13.41	17.71	19.14
5225	71.09	69.39	12.93	12.81	18.19	18.46
5293	67.68	70.28	13.12	13.78	19.39	19.61
5312	67.24	67.29	11.56	13.49	17.19	20.05
5325	70.91	68.58	12.92	13.49	18.22	19.67
5328	75.79	73.83	12.99	11.68	17.14	15.82
5329	73.19	70.97	14.52	14.16	19.84	19.95

Table 9.20 *Measurements A and B on the left and the indices calculated for males on the left (YL) and on the right (YR) for specimens 5359-6409.*

Spec_no	A_Left	A_Right	B_Left	B_Right	YL=B/A*100	YR=B/A*100
5359	72.71	71.03	14.96	15.47	20.57	21.78
5379	70.32	70.06	13.80	13.79	19.62	19.68
5387	77.57	76.18	13.82	13.91	17.82	18.26
5434	70.17	70.32	13.26	12.48	18.90	17.75
5500	69.03	71.69	16.51	16.38	23.92	22.85
5542	72.59	72.06	12.23	14.39	16.85	19.97
5573	68.71	68.47	12.71	13.04	18.50	19.04
5592	71.46	74.96	12.28	13.22	17.18	17.64
5626	74.11	73.43	15.73	15.02	21.23	20.45
5641	64.09	63.81	12.09	12.26	18.86	19.21
5650	70.28	70.93	14.55	15.14	20.70	21.34
5677	69.50	71.13	10.33	10.37	14.86	14.58
5719	69.72	69.10	11.93	11.60	17.11	16.79
5740	71.29	72.06	14.63	14.81	20.52	20.55
5752	71.59	72.06	14.31	12.86	19.99	17.85
5784	73.17	75.02	14.60	14.37	19.95	19.15
5799	71.67	71.74	12.24	11.84	17.08	16.50
5811	65.42	66.76	11.08	11.28	16.94	16.90
5817	73.63	75.94	13.69	13.14	18.59	17.30
5831	70.78	69.57	12.78	12.15	18.06	17.46
5858	74.16	73.36	11.46	11.75	15.45	16.02
5909	73.52	72.90	10.22	10.67	13.90	14.64
5916	71.99	72.06	10.37	10.43	14.40	14.47
5924	75.54	72.87	13.59	13.68	17.99	18.77
5931	72.70	74.21	13.87	14.52	19.08	19.57
6008	73.57	73.18	13.97	14.25	18.99	19.47
6142	75.13	75.12	16.49	17.12	21.95	22.79
6199	73.03	75.56	16.31	16.10	22.33	21.31
6219	70.33	71.64	11.92	12.37	16.95	17.27
6241	72.44	70.69	11.36	12.41	15.68	17.56
6288	71.19	70.74	12.21	13.66	17.15	19.31
6302	70.37	71.36	13.45	12.53	19.11	17.56
6307	73.81	72.86	12.34	12.11	16.72	16.62
6341	69.61	71.23	12.26	12.56	17.61	17.63
6348	70.79	68.16	14.02	13.45	19.81	19.73
6374	68.45	69.18	14.29	14.84	20.88	21.45
6385	69.72	69.67	11.48	11.48	16.47	16.48
6400	67.19	68.59	13.56	13.13	20.18	19.14
6405	72.86	72.68	12.47	12.55	17.12	17.27
6409	77.93	81.76	16.59	16.37	21.29	20.02