THE RETROMOLAR FORAMEN IN THE SOUTH AFRICAN POPULATION: PREVALENCE, STRUCTURE AND CLINICAL SIGNIFICANCE OF AN ANATOMICAL VARIATION

by

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submitted to comply with the requirements for the completion of the degree

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DECLARATION OF ORIGINAL WORK

I, Mohamed Yasin Gamieldien, declare that this thesis,

THE RETROMOLAR FORAMEN IN THE SOUTH AFRICAN POPULATION: PREVALENCE, STRUCTURE AND CLINICAL SIGNIFICANCE OF AN ANATOMICAL VARIATION,

submitted in completion of the requirements of the degree Master of Science Anatomy in the Department of Anatomy, School of Medicine, University of Pretoria, is my own original work and has never been submitted for any academic award to any other tertiary institution.

12/03/2015

MY Gamieldien **Date**

FOREWORD AND ACKNOWLEDGEMENTS

The task of according appropriate acknowledgement to all those who have contributed to this work would be herculean at its smallest extent. As the primary goal of this work is one of academic output, and not the preparation of a Tome of Thanks, I hope that most will be satisfied by the appreciation I have tried to express in person. An attempt will, however, be made at a list of those who have contributed significantly to its completion, whether active in research, displaying generosity in sharing of resources or the stimulation of personal and academic growth.

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ABSTRACT

The retromolar foramen represents a little known anatomical variation in the posterior mandible of uncertain clinical importance. It has been the subject of limited study. Findings and conclusions of these studies have been placed under little scrutiny.

Suggested clinical consequences associated with the presence of the retromolar foramen include local anaesthetic failure, local haemorrhage during surgery, perineural spread of infectious and invasive pathology, and loss of sensation in the normal distribution of the buccal nerve due to surgical intervention. Reports of the possibility of these complications seem to suggest that the retromolar foramen, canal and its associated neurovascular bundle are structures of great clinical importance. Case reports seem to have, however, only included reports of loss of gingival and buccal sensation as a consequence of third molar surgery in the presence of this anomaly.

This study therefore aimed to report the prevalence of the retromolar foramen and canal in the South African population, describe its course and structure, and produce a clinical framework in which to approach the presence of the retromolar foramen. Comparisons between the present and existing studies were made and conclusions concerning the clinical importance of this structure were drawn.

Inspection of a sample containing 946 mandibles was performed. Of these, 885 were regarded as suitable for inclusion. These mandibles were inspected for the presence of a retromolar foramen in which a 1 mm diameter needle could pass through without resistance. The distance from the last tooth in the arch to the retromolar foramen was also measured. Fifty of these mandibles were then randomly selected and scanned using microfocus computed tomography.

Seventy mandibles were found to have at least one retromolar foramen (7.9% of the total sample). No statistically significant differences were found when the presence of the retromolar foramen was correlated with race, sex or age. The finding that sex and age played no significant role in the presence of the retromolar foramen is in agreement with available literature. Detected prevalence seemed to be heavily influenced by the method used to determine the presence of the retromolar foramen.

The average distance between the second mandibular molar and the retromolar foramen was 16.83 ± 5.57 mm and the average distance between the third mandibular molar and the retromolar foramen was 10.47 ± 3.77 mm. These findings were found to be in agreement with most other reports.

Fifty retromolar canals were selected at random and scanned using microfocus computed tomography. Analysis revealed four basic patterns. These were type A, a vertical canal between the inferior alveolar canal and the retromolar area of the mandible, type B, a curved canal taking a recurrent course between the inferior alveolar canal and the retromolar area, type C, a canal with an approximately horizontal path between the inferior alveolar canal and the retromolar area, and the

temporal crest canal (TCC, not designated as type D to create a distinction between it and types A, B and C), a canal terminating on either side of the temporal crest. Type B was the most common presentation (68% of retromolar canals in the study), a finding contrary to that of other studies.

The presence of the retromolar neurovascular bundle is of uncertain clinical importance and requires further anatomical and pharmacological study to determine its effect on local anaesthetic failure. A model in which the retromolar canal branches from the inferior alveolar canal does not seem to support a conclusion in which local anaesthetic failure may be directly attributable the presence of this anatomical variation alone. Classification of the retromolar canal is of limited clinical use and may require a revised scheme if clinical application is sought. Complications associated with the presence of the retromolar foramen are poorly documented and seem to be of little consequence.

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1. INTRODUCTION

The retromolar area of the mandible is a site frequently accessed for surgical intervention by dentists and maxillo-facial and oral surgeons. As such, the importance of intimate knowledge of anatomy and anatomical variations found in this area cannot be understated. This text covers one such variation, the retromolar foramen (RMF). This foramen, which transmits neurovascular elements, is largely unknown (a search on PubMed at the date of writing revealed 27 results for the keywords ‘retromolar foramen’, many of which are not relevant to the anomaly). It is infrequently addressed in anatomical texts and other scholarly works, and much less in dental school curricula.

Clinical importance of the RMF is uncertain. It is found in a triangular area defined between the last mandibular molar (second or third), the external oblique ridge of the mandible, and the attachment of the pterygomandibular raphe. Reports of the anomaly implicate its presence in possible local anaesthetic failure, intra-operative haemorrhage and in post-operative paraesthesia of the normal distribution of the buccal nerve (as discussed in the literature review).

The surgical intervention that typifies access to the area (and the public perception of the field of maxillo-facial and oral surgery in general) is the removal of impacted third molars (so-called “wisdom teeth”). Improved knowledge of this anatomical area could therefore play a role in surgical planning in terms of access, may minimise intra-operative complications and will assist the clinician (especially the inexperienced one) to identifying causes of, and appropriately handle, complications attributed to this variation.

2. LITERATURE REVIEW

Origin of accessory mandibular foramina

A review of existing literature provides two possible theories for the development of the retromolar canal (RMC) and its contents. These two theories seem to be conflicting as there are differences in temporal, anatomical and physiological factors deemed responsible for development of the RMC and the associated RMF. These theories are outlined below:

Chávez-Lomelí *et al.* (1) reported that the mandibular canal arises as at least three separate canals with multiple separate foramina in prenatal life. In a study of a skeletal sample these canals, each with separate canal openings, were visualised by radiographic analysis after placing a radiopaque material (either gutta percha or orthodontic wire) into the canals via the canal openings on the surface of the mandibles. Different canals appeared at different phases of development; the first to appear was the canal to the incisors, second, the canal to the primary molars, and third, one or more canals to the permanent mandibular molars (see figure 2.1). These canals fuse to form the mandibular canal. It is assumed that the classical representation of the mandibular canal: a single unbranching canal (with the exception of its termination and branches directed toward the tooth apices) transmitting a single neurovascular bundle (the inferior alveolar neurovascular bundle) is a consequence of complete fusion of the canals found in this study.

Persistence of these structures (i.e. the multiple mandibular canals and their openings) may explain the phenomenon of variation in mandibular canals and foramina. It is important to note that Chávez-Lomelí *et al.* did not implicate their findings in the development of a so-called RMC or any other variation in the structure of the mandibular canal. Their findings do, however, seem to provide a neat theory to explain development of the RMF and RMC along with other variations of the mandibular canal system.

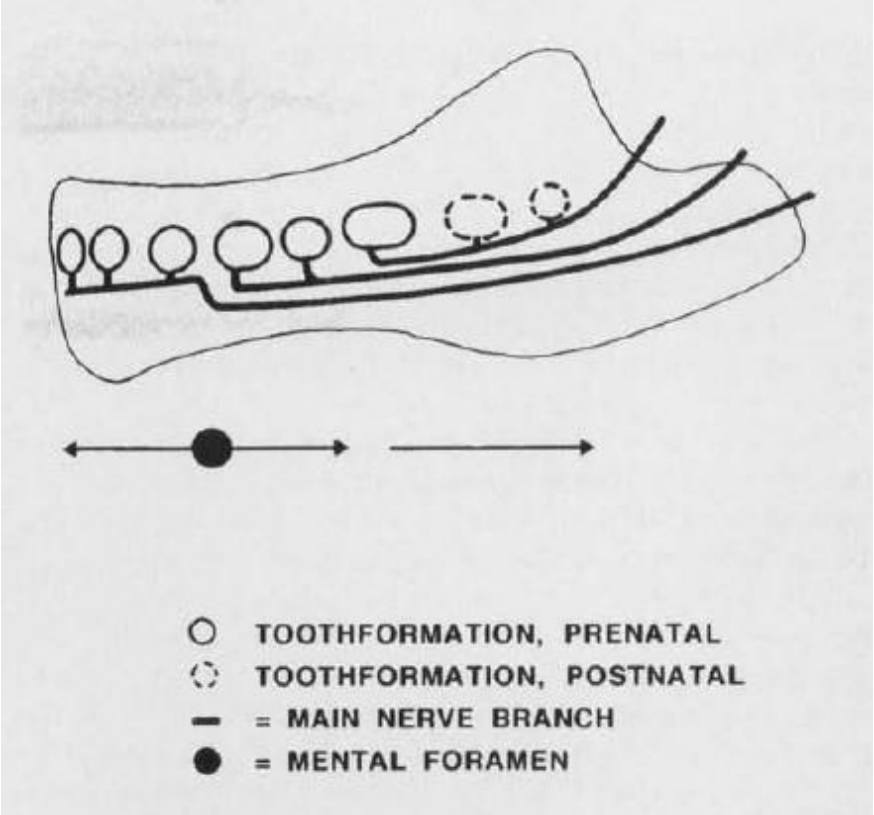

Figure 2.1 – Schematic representation of the development of the mandibular canal as three separate canals. (1)

A competing theory was developed by Ossenberg (2) through her work on a large sample consisting of 2500 mandibles. Ossenberg's sample contained mandibles in which the highest frequency of detected RMF occurred in mandibles belonging to adolescents. This was attributed to an "increased neurovascular requirement" corresponding with increased masticatory forces, third molar (M3) eruption and the adolescent growth spurt. Ossenberg states that variables responsible for the presence and characteristics of these foramina include the branching pattern of the trigeminal nerve (including possible variations thereof) and its interaction with the developing mandible, providing some measure of a possibility of agreement with the theory of persistence of developmental structures. Also suggested is that the presence of the RMF may predominantly be under genetic influence due to differences in populations, presumably living in similar environments with similar lifestyles. Provision for the possibility of environmental influences was made.

Contents of the RMC and their distribution

Wyatt (3), in a 1996 article, asserts that the structures escaping the RMF are devoid of nerve tissue and contain only vascular elements. He says of the structures exiting the RMF (referred to as the "retromandibular foramen" in the article): "When seen clinically there does not seem to be an accompanying nerve". Many studies which included histological analysis show evidence contrary to this claim.

In a dissection of 18 specimens, 13 of which contained the RMF, Schejtman *et al.* (4) found that structures exiting the RMF arise from the inferior alveolar neurovascular bundle (or at least communicate with it; one case is described as having an interruption in these elements with the bone being pierced by structures from outside of the bony mandible). It was found that these elements may constitute a neurovascular bundle, may be composed of mostly neural structures or may be purely vascular. Their dissections revealed variable courses of these elements but showed a preference for distribution along the tendon of the temporalis muscle, the buccinator muscle, the posterior reaches of the mandibular alveolar process and distribution to the mandibular M3.

Singh (5) reported a nerve arising from a foramen in the retromolar fossa discovered upon M3 surgery. The nerve was damaged and a biopsy performed. Histopathological analysis revealed myelinated nerve fibres. During a follow-up examination the patient reported the presence of paraesthesia in the buccal sulcus and facial gingiva. The distribution of the described paraesthesia included the canine region and extended posteriorly to the retromolar area, roughly corresponding to the area usually supplied by the buccal nerve. These findings suggested that the structure contained within the RMC was an aberrant buccal nerve. Connection with the inferior alveolar neurovascular bundle could not be clearly established as further dissection was not possible.

At least two more studies report biopsy of the structures exiting the RMF during M3 surgery. Bilecenoglu and Tuncer (6) reported that histological analysis of the

biopsied tissue revealed myelinated nerve fibres, an artery, venules and striated muscle fibres. A 2011 article by von Arx *et al.* (7) (Swiss literature – German language with English abstract) reported similar results – the structure escaping the RMF contained myelinated nerve fibres, arteries and venules (see figure 2.2).

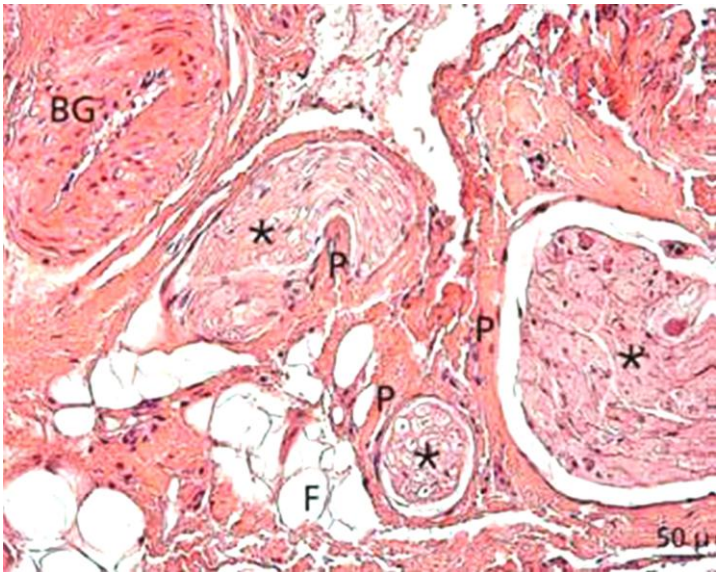

Figure 2.2 – Transverse section through structures exiting the RMF. (BG – blood vessels, F – adipose tissue, asterisk – nerve) (7)

Carter and Keen (8), in a series of eight dissections, showed communication between neurovascular bundles associated with the temporalis muscle with those entering the mandible at a foramen in the retromolar fossa. These eventually established connection, through a variable route, with the inferior alveolar nerve or the dental branches supplying the mandibular molars. Three of their dissections revealed direct communication between branches of this bundle and the roots of the first mandibular molar (M1) and M3. Histological analysis of the structures transmitted through the RMF consistently revealed the presence of nerve fibres and vascular elements.

Fukami *et al*. (9) reported biopsy of the contents of a bifid mandibular canal which opened up into a foramen in the retromolar area. Histological analysis found nerve bundles and arteries.

The temporal crest canal (TCC) described by Ossenberg (2, 10) may have a foramen resembling that of the RMF. The TCC terminates in foramina on either side of the temporal crest with the canal between them (see figure 2.3). This was said to probably contain the buccal nerve and may possibly also have transmitted blood vessels (impossible to determine as the study was performed on dry mandibles). Ossenberg considered the TCC a subtype of the RMF.

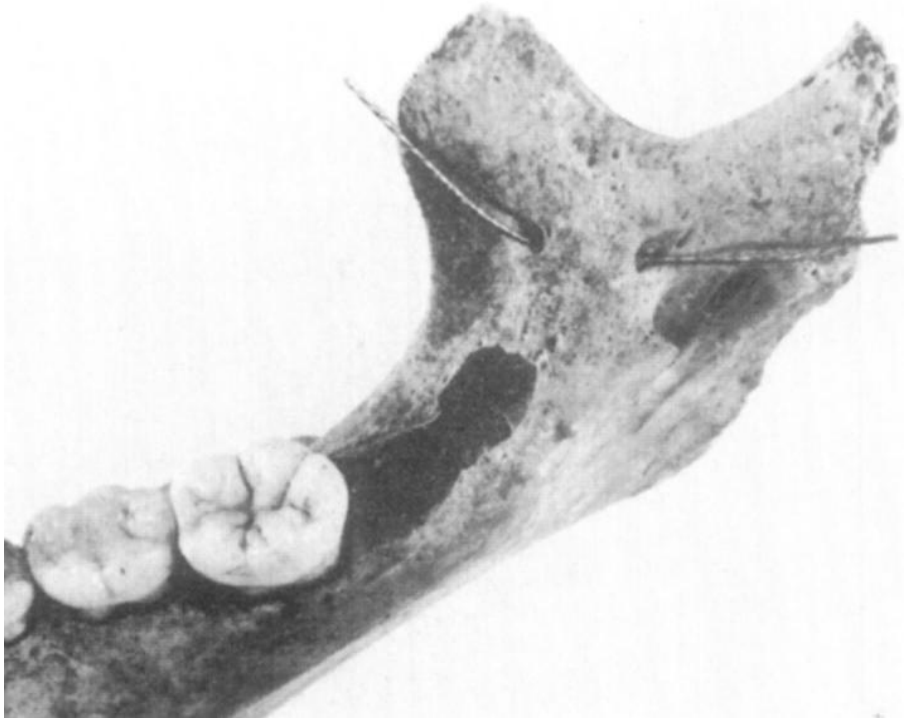

Figure 2.3 – Ossenberg's TCC showing communication between both sides of the temporal crest. (10)

2.1 Prevalence of the RMF in the South African population

No reports of the prevalence of the RMF in the South African population are available. An article published in July of 1977 by Nortje *et al*. (11) described a variation seen on panoramic radiographs (PAN) in which a duplicated inferior alveolar canal took the form of a “short upper canal extending to the second molar or third molar teeth”. There is no indication that this canal terminated on the surface of the mandible in the retromolar area (in the fashion of what can be described as an example of the RMC). The article does however state that this variation is probably the same as that described in the type 2 variation of Carter & Keen (8): a variation in which a branch of the inferior alveolar nerve gives off a branch projecting towards the surface of the retromolar fossa (see figure 2.4).

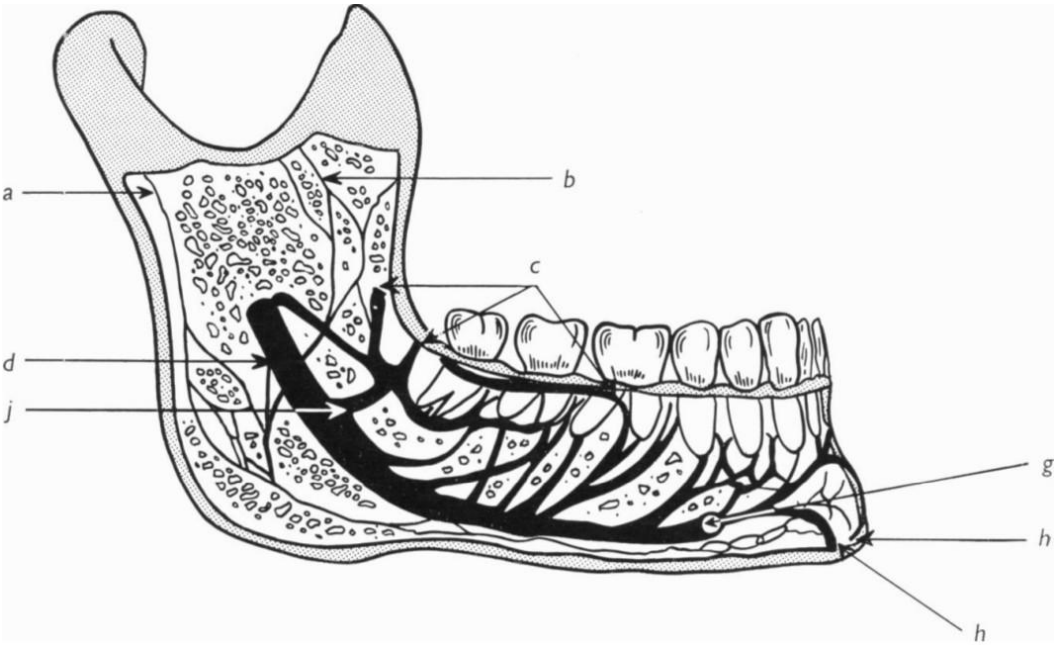

Figure 2.4 – Type 2 arrangement according to Carter and Keen (a – communication between plexus in ramus and insertion of lateral pterygoid muscle, b – communication between plexus in ramus and insertion of temporalis muscle on coronoid process, c – large communicating branches passing through foramina in retromolar fossa, d – lateral view of inferior alveolar neurovascular bundle, g – mental nerve, h – neurovascular communicating branches passing through foramina near mental spine). (8)

A later article by Nortje *et al*. showed an example of the RMC. (12) As the study on South Africans by Cater and Keen (8) served mostly to demonstrate patterns of variation and did not serve to clearly present the prevalence of these variations, it is unknown whether or not reports of the prevalence of the RMF in the South African population exist at the time of writing. Ossenberg (2) makes reference to black Africans, but does not include details of nationality.

A wide variation in the prevalence of the RMF in different populations has been documented. This prevalence ranges from a low of 0% in both black African and black American mandibles (2) to a high of 72% in the mandibles of Argentine aborigines. (13) Table 2.1 adapted from a 2013 article by Potu *et al.* (14) gives an overview of studies reporting the prevalence of the RMF.

Table 2.1 – RMF prevalence in different studies (adapted from Potu *et al.*) (14)

AUTHOR	POPULATION	n	RMF (%)
Ossenberg (2)	Black African	19	0
	Black American	33	0
	Canadian Caucasian	11	9.1
	Indian	153	5.9
	Italian	86	8.1
	Siberian Natives	167	3.2
	Native Americans:		
	Illinois Hopewell	99	1.0
	Plains Indians	435	8.0
	Northern Indians	178	15.2
	Eskimo (Inuit)	485	8.2
	Aluet	192	15.1
	Japanese populations:		
	Neolithic (Jomon)	57	3.5
	Ainu	70	10.0

Table 2.1 cont.

	Unspecified	94	3.2
Bilecenoglu &Tuncer (6)	Turkish	40	25
Schejtman *et al*. (13)	Argentine aboringine	18	72
Sawyer & Kiely (15)	American	234	7.7
Kodera & Hashimoto (16)	Japanese	41	20
Pyle *et al*. (17)	Caucasian, African American	475	7.8
Narayana *et al*. (18)	South Indians	242	21.9
Priya *et al*. (19)	Indians	157	12.7
Suazo *et al*. (20)	Brazilian	294	12.9
von Arx *et al*. (21)	Swiss	121	25.6
Kawai *et al*. (22)	Japanese	46	52
Motta-Junior *et al*. (23)	Brazilian	35	17
Lizio *et al*. (24)	Italian	233*	14.6
Rossi *et al*. (25)	Brazilian	222	26.6
Orhan *et al.* (26)	Turkish	242	23.1

*This figure represents hemimandibles rather than full mandibles.

The wide variation in RMF prevalence between populations may be due to factors inherent in local populations (genetic or environmental), criteria for RMF inclusion and study design (e.g. radiographic survey, inspection of dry mandibles with or without minimum RMF diameter, etc.), and the use of samples of relatively small size by some investigators (producing a less robust dataset). It is also important to point out the presence of little agreement between authors who have studied the same populations. This may be due to the method of identification, differences in inclusion and exclusion criteria, or factors due to differences in local populations within a given country.

The methods of identification of the RMF described in literature are at least two. These two methods are direct inspection of skeletal samples (with or without applying a minimum defined diameter to an opening in the retromolar area) and

radiographic analysis of existing patient cone beam computed tomography (CBCT) scans.

Studies in which the prevalence of the RMF was determined by inspection of dry mandibles include those conducted by Ossenberg (2), Bilecenoglu and Tuncer (6), Schejtman *et al*. (13), Kodera and Hashimoto (16), Pyle *et al*. (17), Narayana *et al*. (18), Priya *et al*. (19), Suazo *et al*. (20), Motta-Junior *et al*. (23), and Rossi *et al*. (25) Most investigators did not place a lower limit on the RMF diameter for inclusion in the study (i.e. every 'foramen' observed in the retromolar area which did not resemble a product of decay of the bony material was included as a positive RMF).

The study by Ossenberg (2) along with that by Bilecenoglu and Tuncer (6) used a minimum diameter of 0.5 mm as an inclusion criterion. Narayana *et al.* (18) collected data on all visible foramina in the retromolar area but divided their sample into those which contained a possible RMF with a diameter of less than 0.5 mm and those with a diameter greater than 0.5 mm. They used a radiopaque dye (angiograffin) to stain the canals and then studied them radiographically (see figure 2.5). Canals in cases which an identified RMF had a diameter of less than 0.5 mm were invariably blocked, making studying RMCs using this method impossible (the dye would not flow through the blocked canal).

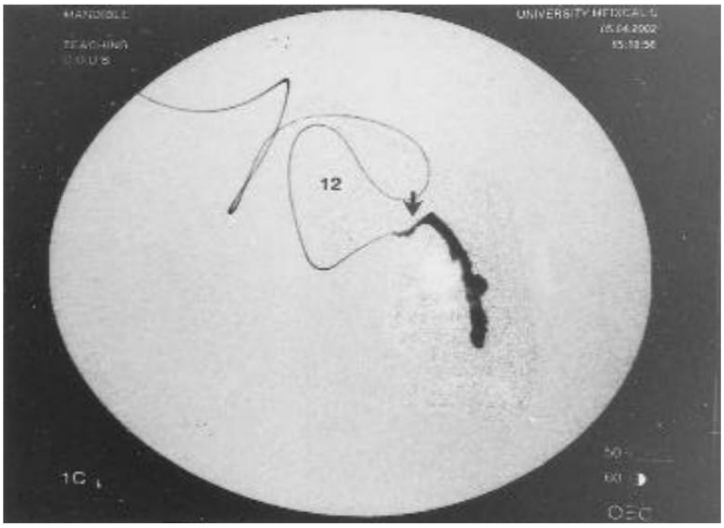

Figure 2.5 – Use of the radiopaque dye angiograffin to stain the RMC to facilitate radiographic analysis. (18)

CBCT was used to determine the prevalence and structure of the RMC by von Arx *et al*. (21), Kawai *et al*. (22), Lizio *et al*. (24) and Orhan *et al.* (26) All, with the exception Kawai *et al.* (22), used existing CBCT scans of living patients to determine the presence of the RMC. They scanned cadavers to determine the presence of the RMC. CBCT evaluation in a living patient allows for accurate determination of whether an assumed RMF does, in fact, communicate with the inferior alveolar canal, avoiding the problems of blocked canals encountered by Naryana *et al*. (18)

Von Arx *et al.* (21) made a comparison between the use of PANs and CBCT scans to determine the presence of the RMC in a given patient. Of the 31 CBCT detected RMCs in their study, only seven were found upon examination of PANs of the same patient. It was thus demonstrated that the use of a PAN is a comparatively poor method of determining the presence of the RMF preoperatively (see figures 2.6 and 2.7). This fact, coupled with gains made by advances in imaging technology, might explain the inability of Nortje *et al*. to detect even one single RMC in their large set of

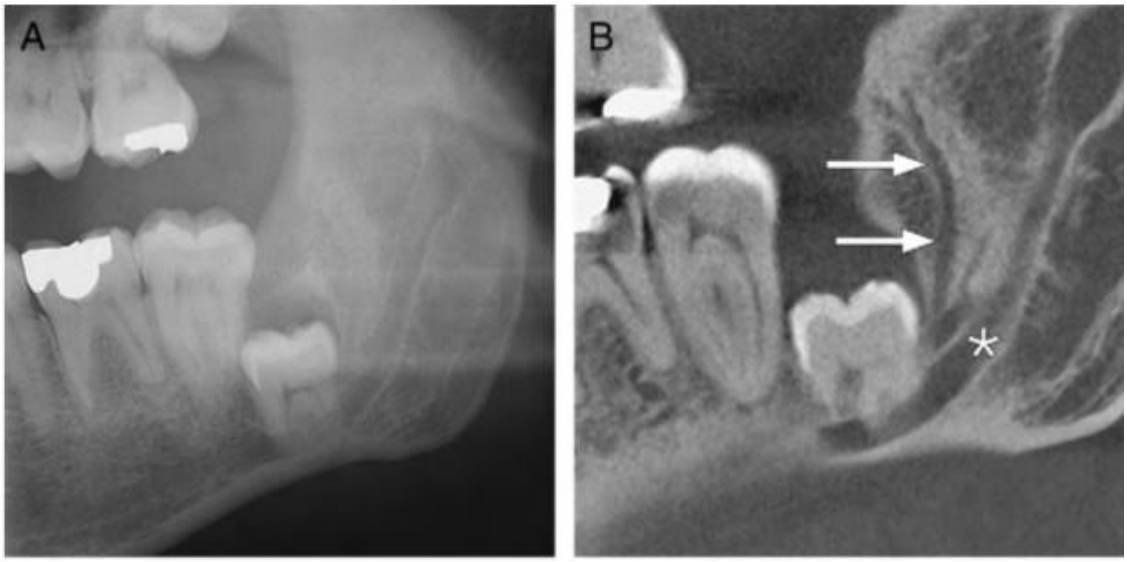

Figure 2.6 – Comparison between the CBCT scan and a PAN of the same patient where the RMC is not clearly discernable on the PAN. A) PAN without a clear RMC (not clearly visible as a canal between the retromolar area and the inferior alveolar canal); B) Sagittal view of the RMC (arrows) descending into the inferior alveolar canal (asterisk). (21)

3612 PANs. (11) The presentation of the RMC by Nortje *et al*. in a later paper and their conclusion that it is an extremely rare variation seems to be a direct result of the limitations of their study design (see figure 2.8). (12)

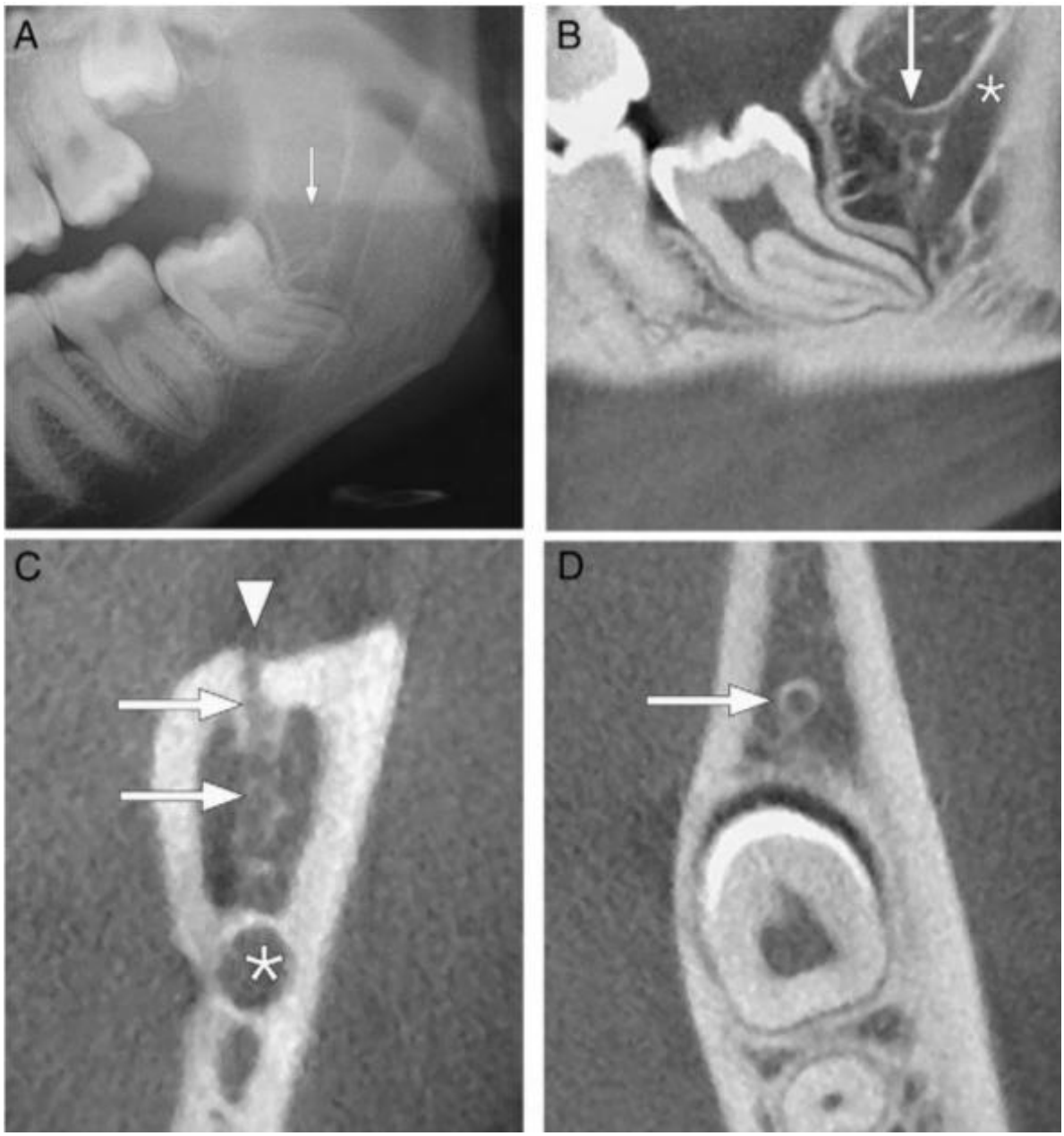

Figure 2.7 – Comparison between the CBCT scan and a PAN of the same patient where the RMC is clearly visible on the PAN. A) outline of the RMC on a PAN (arrow); B) Sagittal view of the RMC (arrow) descending into the inferior alveolar canal (asterisk); C) coronal view of the RMC (arrow) descending into the inferior alveolar canal; D) axial view of the RMC (arrow) seen posterior to an impacted M3. (21)

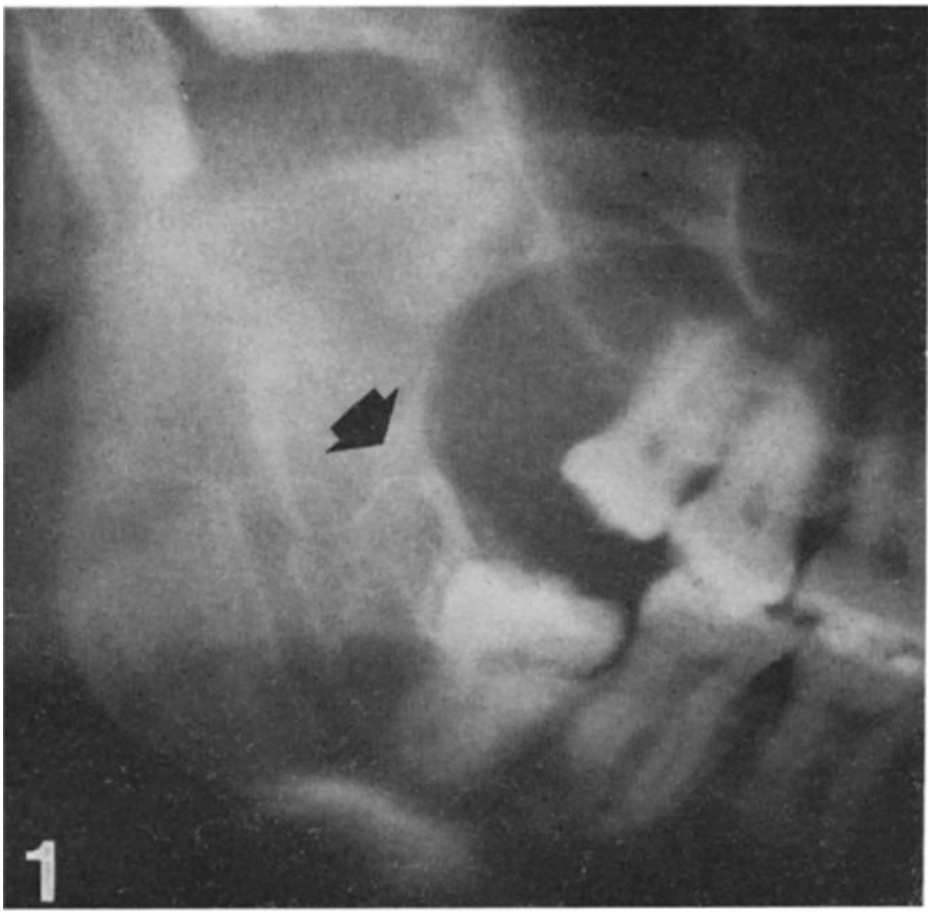

Figure 2.8 – RMC visible on a PAN (arrow) presented in an article by Nortje *et al*. Their study was performed before the widespread use of digital radiography (digital radiography allows for easy image manipulation for optimal visualisation of anatomical structures on PANs). (12)

The effect of sex on the prevalence of the RMF

Ossenberg (2), Kodera and Hashimoto (16), Pyle *et al*. (17), Suazo *et al*. (20), and Von Arx *et al*. (21) reported no statistically significant effect of sex on the presence of the RMF. Orhan *et al*. (26) reported a small female preference for the RMF – 15.4% were found in CBCT scans of male patients and 19% were found in CBCT scans in female patients. If sex plays any role in the presence of the RMF, it would seem that it is a relatively minor one.

Reported side preference of the RMF

Bilecenoglu and Tuncer (6) reported no significant role of sidedness on the presence of the RMF. Five out of 40 mandibles presented with the RMF on the right and seven out of 40 mandibles presented with the RMF on the left. Ossenberg (2), whose sample consisted of a fairly large number of different populations, came to the conclusion that in populations where the frequency of the RMF was low, a preference for right sidedness in unilateral presentations was found and in populations where the RMF frequency was high a left sided tendency was exhibited. There were no statistically significant preferences between sides in so-called New World populations (i.e. those populations native to the Americas). By contrast Old World populations showed a greater tendency for right-sided distribution. Ossenberg admitted that these differences were puzzling. Narayana *et al*. (18) showed a slight tendency for right sidedness of the RMF in unilateral presentations (7.1% of mandibles had the RMF only on the left while 10.7% of mandibles had the RMF only on the right). Suazo *et al*. (20) also reported no significant differences between left and right sided appearance of the RMF with 4.4% of mandibles showing the RMF on the left and 4.8% showing the RMF on the right. The sample studied by Rossi *et al*. (25) showed a left sided RMF in 18.92% of mandibles studied and a right sided RMF in 16.22% of mandibles studied. Orhan *et al*. (26) reported a 20% prevalence of right sided RMF and a 14.6% prevalence of left sided RMF. Von Arx *et al*. (21) reported more RMCs on the left, but the difference was not statistically significant.

The effect of age on the presence of the RMF

Ossenberg (2) reported a peak in the adolescent cohort. She suggested that the possible influence of an increased neurovascular requirement related to the adolescent growth spurt and the eruption of M3 coupled with an increase in masticatory strength resulted in the increased RMF prevalence in adolescence.

The association between the RMF and the last tooth in the arch

Bilecenoglu and Tuncer (6) found that the dimensions of the retromolar trigone had no statistically significant association with the presence of the RMF or its distance from the last tooth in the arch. The presence of M2 or M3 as the last tooth in the arch played no statistically significant role in the presence of the RMF. The average distance of the RMF from M2 was 11.9 ± 6.7 mm and the average distance between M3 and the RMF was 4.2 ± 2.3 mm. Figure 2.9 shows the distribution of the RMF in the retromolar area according to data collected by Bilecenoglu and Tuncer. Motta-Junior *et al*. (23) reported an average distance of 8.99 ± 4.06 mm between the RMF and M3.

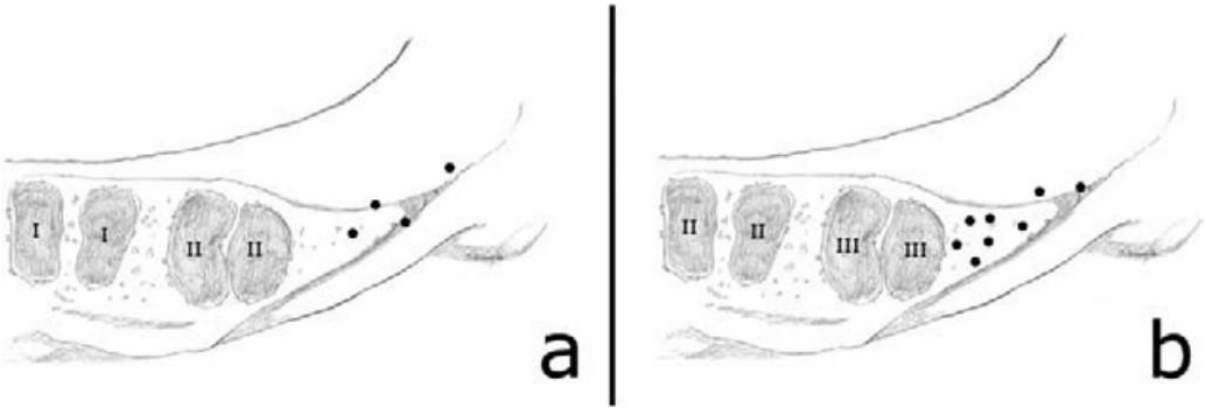

Figure 2.9 – Distribution of the RMF in the retromolar area posterior to M2 (a) and M3 (b). Roman numerals indicate alveoli of associated molars (I – M1, II – M2, III – M3). (6)

Von Arx *et al*. (21), in a CBCT study, measured the distance from the midpoint of the RMF to the cemento-enamel junction (CEJ) of M2 using sagittal sections (see figure 2.10). They found an average distance of 15.16 ± 2.39 mm with a range of 12.32 – 22.32 mm. No measurements from M3 were reported. Kawai *et al*. (21) found the RMF an average of 14.4 mm from the posterior border of M2. Motta-Junior *et al*. (23) reported an average distance of 8.99 mm ± 4.06 mm between the RMF and M3.

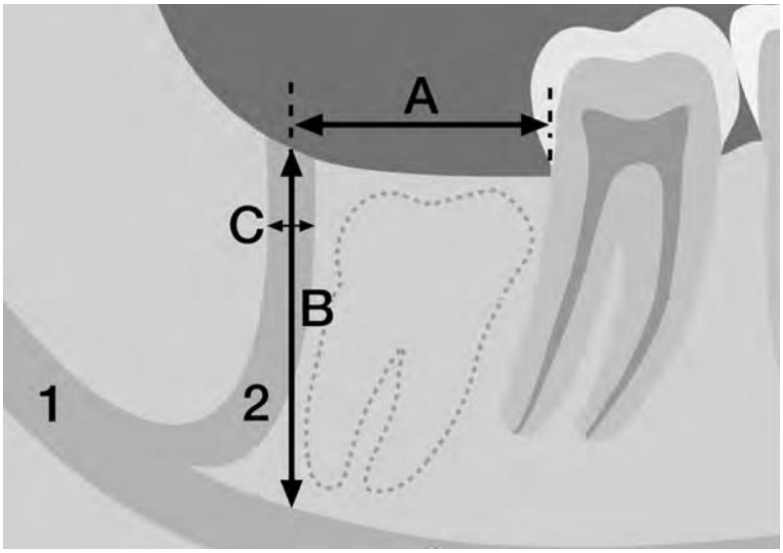

Figure 2.10 – Schematic representation of a sagittal section of the mandible which includes the retromolar area, showing the RMC and adjacent structures (A – distance from the middle of the RMF to the CEJ of M2, B – distance from the surface of the bony mandible to the inferior alveolar canal, containing in its length the RMC, C – width of the RMC, 1 – inferior alveolar canal, 2 – RMC). (21)

2.2 Characterisation of the internal structure of the RMC using Microfocus computed tomography (MicroCT)

To date, determination of the internal structure of the RMC has been through one of four means:

1. Destructive exploration of the RMC by dissection of the mandibular bone;
2. Use of wire alone (i.e. without imaging) to determine the path of the RMC;
3. Use of plain radiographs to determine the internal characteristics of the RMC;
4. CBCT analysis to determine RMC characteristics.

No reports of the use of MicroCT to determine the characteristics of the RMC have been found.

Destructive exploration of the RMC by dissection of the mandibular bone

Both Schejtman *et al*. (4) and Carter and Keen (8) used this method to determine the internal characteristics of the RMC. Schejtman (4) reported two basic patterns and other variations showing an irregular appearance (described as being interrupted by what was vaguely called ‘elements’ and various other canals running through the bone). One of the described forms displayed a posterior superior (recurrent) course, terminating in one or more foramina in the retromolar area. Another variation showed an anterior course along a line almost parallel with the inferior alveolar canal.

Carter and Keen (8) described the presence of foramina in the retromolar area, showed a radiograph and mandibles with RMCs and produced multiple drawings of canal patterns with branches terminating in the retromolar area. They reported that one third of posterior mandibular foramina (i.e. accessory foramina) occurred in the retromolar area.

Use of wire alone to determine the path of the RMC

Ossenberg (2) passed a wire through the RMF to determine the pattern of interaction between the RMF and the inferior alveolar canal. Three different basic patterns were found:

1. Type A – RMC branching off the inferior alveolar canal projecting posterior superiorly in a recurrent path to terminate in the retromolar area;
2. Type B – RMC branching from the inferior alveolar canal taking an anterior course (as opposed to the recurrent posterior superior course taken by the type A canal);
3. Type C – A variant of the RMF with a canal piercing what is described as the temporal crest (the canal does not arise from the inferior alveolar canal) – the TCC.

Type A was the most common presentation (though the prevalence of this variation in the sample was not given). The prevalence of type B canals was intermediate between type A and type C. Type C was the least common variation with less than 2% of canals falling into this category. Ossenberg claims that RMC types A and B were similarly described by Schejtman *et al*. (4) Though no direct visualisation of the RMC is possible in this form of study, assessment of the curvature of the wire provides a means for estimation of the shape of the RMC.

Use of plain radiographs to determine the internal characteristics of the RMC

Narayana *et al*. (18) used plain radiographs to determine the course of the RMC. A radiopaque dye (angiograffin) was introduced into the RMF to allow for easier identification of the RMC and its relationship with the inferior alveolar canal. Three distinct RMC patterns were seen and were given the designation type I, type II and type III. Type I, the most common variation, was described as descending into the mandible vertically from the RMF terminating in the inferior alveolar canal. This type accounted for six of the RMCs (in five mandibles). Type II RMCs, described as

having a largely horizontal course from the RMF before running a short vertical course to terminate in the mandibular foramen, accounted for four of the RMCs (in three mandibles). From the description given, type III canals seemed similar to type I canals, but “with another canal traversed anteriorly from the anterior aspect”. It is not clear what exactly is meant by this variation and the figure given as an example does not do much to clarify the description (see figure 2.10). Two type III RMCs were described in two mandibles. Type I is an analogue of Ossenberg’s type A with type II being an analogous to Ossenberg’s type B. Due to the unclear description, it is uncertain whether or not type III is comparatively similar to any RMC configurations described by other authors.

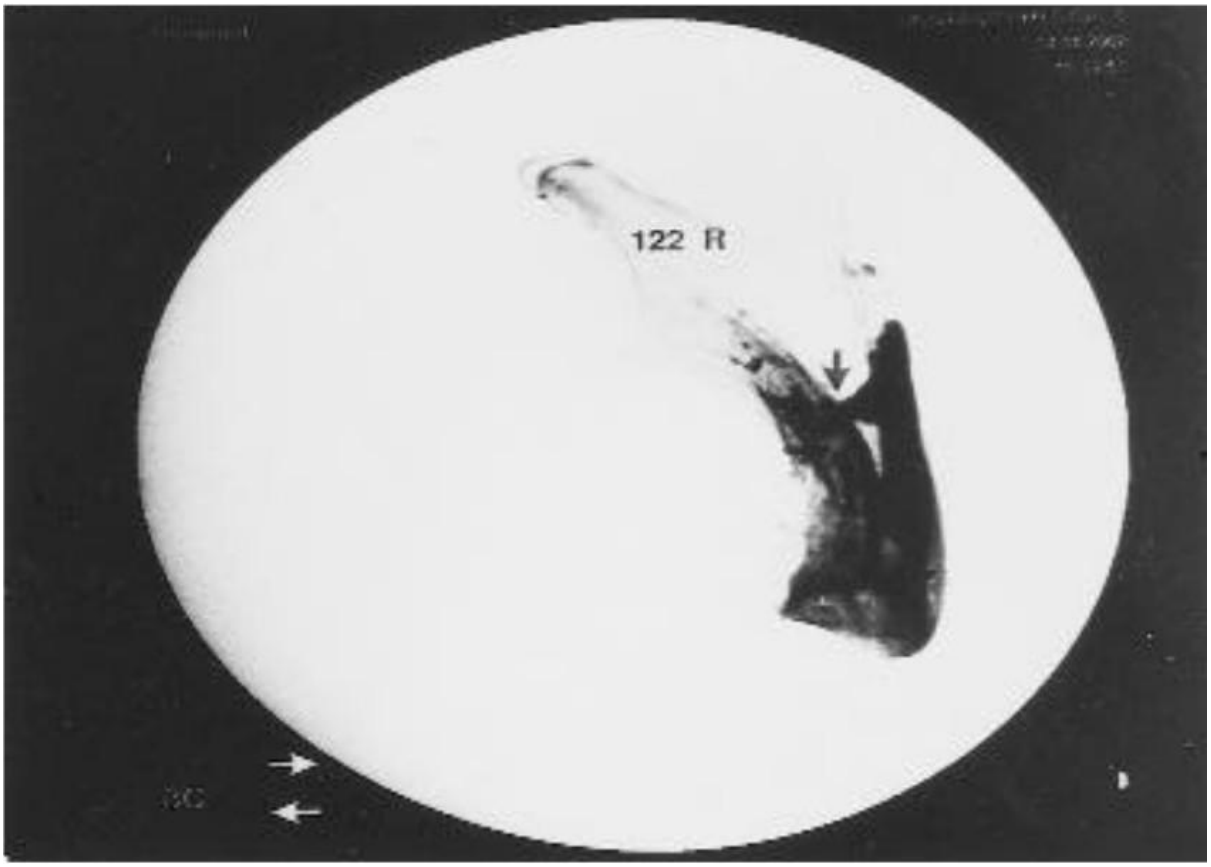

Figure 2.11 – Type III RMC described by Naryana *et al*. (18)

The use of panoramic radiography on living patients the determine presence of the RMC is unreliable at best. In a large series of 3612 PANs, Nortje *et al*. (11) failed to

detect even a single RMC. Von Arx *et al*. (21) found that only seven of 31 RMCs discovered on CBCT scans were visible on PANs of the same patients.

CBCT analysis to determine RMC characteristics

The latest technique used in the assessment of the RMC is CBCT. A CBCT scan is acquired through capturing of multiple exposures of a single mandible around a single axis. These images are then processed to recreate a 3D tomogram of the mandible.

Naitoh *et al*. (27) compared CBCT scans to conventional multislice computed tomography (MSCT) scans for imaging of fine structures of the mandible. CBCT and MSCT scans of the same patients were assessed and compared. The structures evaluated included the RMC. They found that the resolution of the MSCT may, in certain cases, be lower than what can be considered ideal for resolving fine details of smaller canals. They also found that the presence of metal (e.g. in dental restorations) close to the area of interest obscured the image to a greater extent on MSCT scans when compared to CBCT scans. Despite this they concluded that CBCT and MSCT are practically equivalent in their ability to detect fine mandibular structures.

Fukami *et al*. (9) compared the use of a PAN, CBCT and MSCT on a single cadaver with bilateral RMCs. The cadaver was then dissected and the mandible sectioned. They reported that both RMCs were visible on CBCT and MSCT but only one RMC was visible on the PAN (left side). They reported difficulty in discriminating between the RMC and the trabecular bone on MSCT scans. CBCT allowed for easier distinction due to its ability to produce a clearer image (see figure 2.12).

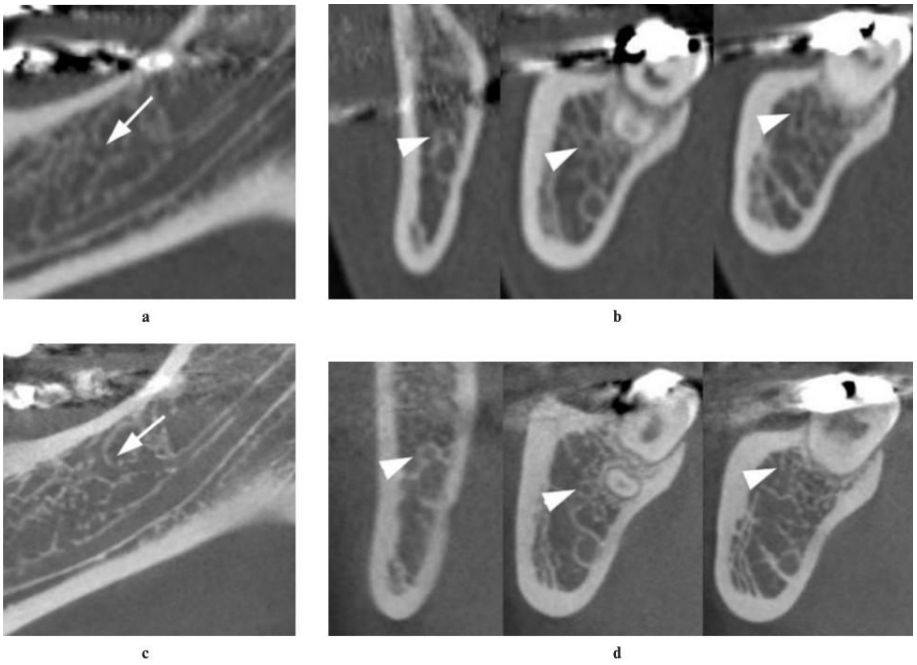

Figure 2.12 – Comparison between MSCT (above) and CBCT (below) images of the same patient. The improved clarity and ability to distinguish trabeculae in cancellous bone from the RMC (arrows) renders CBCT superior to MSCT for the task of detecting RMCs. A) Sagittal section of the RMC using MSCT; B) coronal sections of the RMC using MSCT; C) Sagittal section of the RMC using CBCT; D) coronal sections of the RMC using CBCT. (9)

A few studies have used CBCT to estimate the prevalence of the RMC. These studies include those by von Arx *et al*. (21), Kawai *et al*. (22), Lizio *et al*. (24) and Orhan *et al*. (26)

Internal configuration of the RMC

Wyatt (3) insisted that classification of the RMF and RMC was not useful and might rather be cause for confusion. Despite this insistence there have been at least three different ways in which the RMC has been grouped. These groupings either list the RMC as one variation of a bifid mandibular canal or look at RMCs in isolation.

Ossenberg's scheme (described earlier), can be seen in figure 2.13. The TCC is included as a variant of the RMC but it does not branch off the inferior alveolar canal as types A and B do.

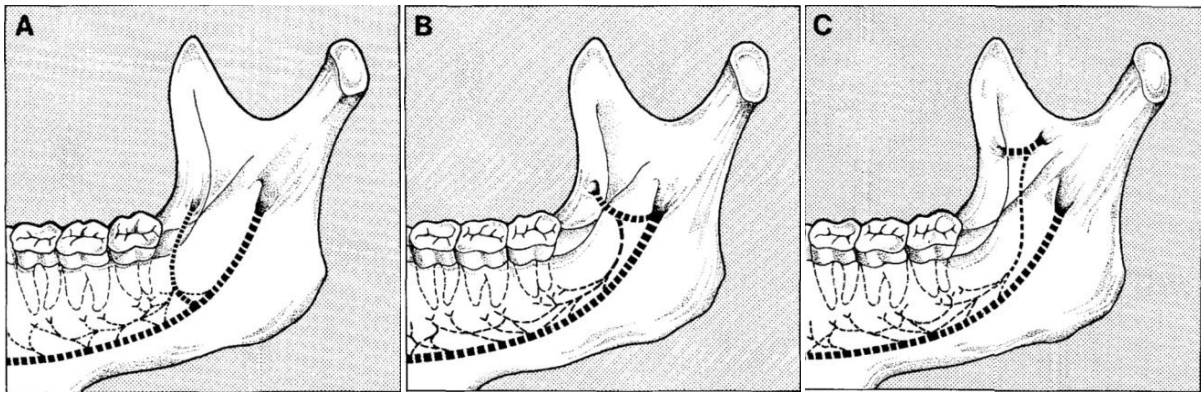

Figure 2.13 – Ossenberg's arrangement: Types A, B and C. (2)

Narayana *et al*. (18) (as described in earlier sections) also classified RMCs into different types: type I, II and III. Although some similarities existed between this scheme and the scheme described by Ossenberg (2), their type III was not clearly defined. Von Arx *et al*. (7, 21), and later Potu *et al*. (14), used what was described as a mix of the two schemes with the obvious exclusion of the TCC (see figure 2.14).

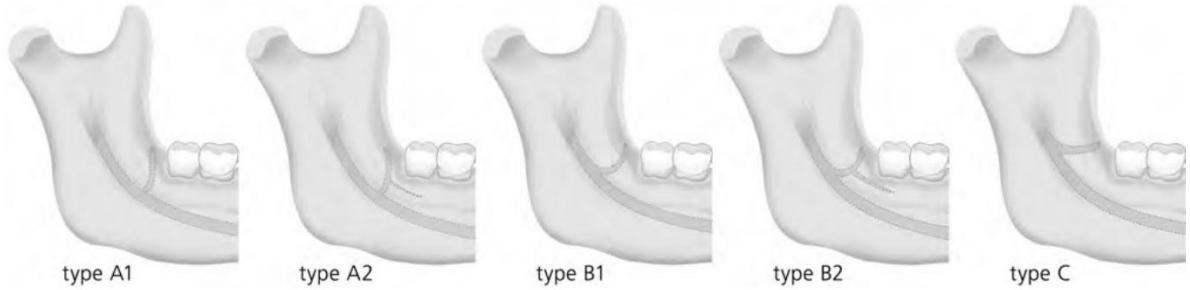

Figure 2.14 – Classification scheme used by von Arx *et al*. (21) to describe the RMC. Note that no provision for the TCC is made in this scheme.

The use of MicroCT for anatomical studies and workflow at MIXRAD

No previous reports of a MicroCT study of the RMC seem to exist. MicroCT is typically used in the field of geosciences, but wide application is possible due to its ability to visualise structures at micron-level resolution in a non-destructive manner. The MIXRAD facility at Pelindaba, housing the South African Nuclear Energy Corporation's (Necsa) MicroCT unit, has been used in various fields of study including anatomy, coal sciences and agricultural sciences.

The advantages of using MicroCT over conventional medical CT (whether CBCT or MSCT) are twofold: first, it reduces the use of clinical time for research purposes ensuring uninhibited access to these facilities for clinicians. Secondly, it is typically able to produce tomograms with a spatial resolution of 0.001 – 0.006 mm (compared to a typical spatial resolution on the order of 0.500 mm for medical CTs). The disadvantage of this system is the time consuming nature of image acquisition, computing power needed for image processing and analysis, and the sheer size of the acquired data (datasets up to 30 GB).

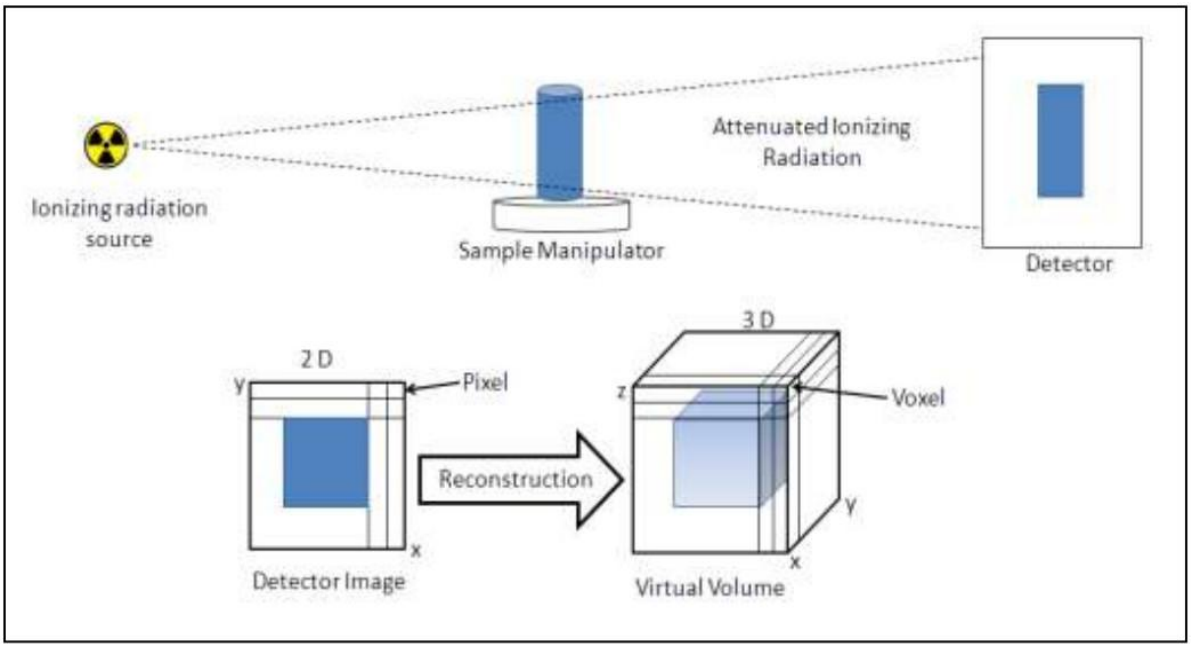

Figure 2.15 – Process of microfocus tomography at Necsa's MIXRAD facility. (28)

Projections are stored in the Tagged Image File Format (TIFF). 3D tomograms are then reconstructed from these 2D projections. Figure 2.15 outlines the standard workflow procedure at Necsa's MIXRAD facility as described by Hoffman and de Beer. (28)

2.3 Production of a clinical guideline on the approach to the possible existence of the RMF and management of associated complications

Complications normally associated with the presence of the RMF are three: local anaesthetic failure (3, 6, 7, 8, 9, 10, 18), intra-operative bleeding (3, 6, 9) and paraesthesia (3, 5, 9, 18) in the normal distribution of the buccal nerve. Schejtman *et al*. (4), in their 1967 article, reported the existence of neural and vascular elements in the contents of the RMC, but did not report on complications associated with their presence.

Local anaesthetic failure

Meechan (29) divided reasons for local anaesthetic failure into operator related and patient related failure. Operator related factors are largely due to poor technique used for administration of local anaesthetic solution. Patient factors include anatomic variation (possibly including variations like the RMC), pathological change (e.g. presence of infection at the site of local anaesthetic injection) or psychological factors (e.g. anxious patients who react to manipulation of oral structures even in the presence of profound anaesthesia).

Wyatt (3) reported the possibility of local anaesthetic failure without acknowledging the possibility that the RMF contains anything other than vascular elements. Bilecenoglu and Tuncer (6) reported the importance of the RMF as a variation due to the possibility of local anaesthetic failure associated with it. Von Arx *et al*. (7) indicated that sensory fibres entering the RMC from above (i.e. as a branch of the buccal nerve rather than a branch of the inferior alveolar nerve) may evade local anaesthetic solution and provide reason for local anaesthetic failure. Carter and Keen (8) reported the possibility that these posterior mandibular foramina provide alternate “escape routes” for sensory innervation explaining persistent pain during

dental procedures after the provision of inferior alveolar nerve anaesthesia. Fukami *et al*. (9) suggested that the contents found in the RMC may result in problems associated with provision of local anaesthesia. Narayana *et al*. also reported on the possibility of neurovascular elements in the RMC "escaping anaesthesia", leading to pain during dental procedures. (18)

Ossenberg's (10) report on the TCC described local anaesthetic failure as a consequence of this variation. She advised on administration of local anaesthetic through a high block technique over the conventional approach to inferior alveolar nerve anaesthesia at the bony lingula of the mandible.

Intra-operative bleeding

Wyatt (3) reports the possibility of intra-operative bleeding but does not state experiencing such a complication in his case report. Bilecenoglu and Tuncer (6) suggested that the presence of the RMF may explain local haemorrhage of unknown cause during oral surgery in the retromolar area. Due to the make up of the contents of the RMC, Fukami *et al*. (9) envisaged the possibility of local haemorrhage.

Paraesthesia

Wyatt (3) reported partial paraesthesia for a short time after removal of M3 in the presence of the RMF. No attempts were made at evaluation of this RMF to limit the possibility of related complications. He does, however, not indicate the anatomic distribution of this paraesthesia. He even states (using macroscopic analysis only) that the elements exiting the RMF are only vascular (no nerve tissue) which seems contradictory to his finding of paraesthesia. If loss of sensation was not due to damage to nerve tissue associated with the contents of the RMC, this paraesthesia may have been due to direct or indirect trauma to the inferior alveolar nerve, a

possibility he did not state. Paraesthesia in such a scenario would have a different distribution.

Singh (5) reported paraesthesia in the buccal sulcus after to trauma to a “slender nerve” encountered in the retromolar area. This nerve arose from the RMF. No unusual bleeding or local anaesthetic failure was reported due to the presence of this nerve.

Von Arx *et al*. (7) stated that anatomic variation such as the RMC may be responsible for the presence of post-operative sensory disturbance in the normal distribution of the buccal nerve. Fukami *et al*. (9) suggested the possibility of paraesthesia due to the characteristics of the contents of the RMC. Narayana *et al.* (18) stated an increased risk in neurosensory disturbance associated with communication of the RMC with the corticated surface of the mandible. Von Arx *et al*. (21), in a later study, saw the aberrant path of the buccal nerve as a risk for sensory disturbance.

Other complications

The possibility of the RMC as a pathway for perineural spread of infection or other pathology was raised by Bilecenoglu and Tuncer. (6) Fukami *et al*. (9) speculated that formation of a traumatic neuroma may be a possible consequence of surgery in the retromolar area in the presence of bifid mandibular canals (including RMCs). No reports of these complications have been found.

3. AIM AND OBJECTIVES

The aim of this study was to determine the prevalence, structure and clinical significance of the RMF in the South African population. The stated aim was addressed through completion of the following objectives:

1. To determine the prevalence of the RMF in the South African population and the average distance from the RMF to the last mandibular molar (whether M2 or M3);

2. Characterisation of the internal structure of the RMC using MicroCT;

3. Production of a clinical guideline to provide clinicians with a framework in which to approach the possible existence of the RMF and facilitate management of associated complications.

4. MATERIALS AND METHODS

4.1 The prevalence of the RMF in the South African population

4.1.1 Inspection of mandibles

All available dry mandibles in the Pretoria Bones Collection housed within the Department of Anatomy at the University of Pretoria were examined by two investigators. Only mandibles judged to be morphologically representative of typical adult mandibles were included (figure 4.1 shows an example of a mandible considered atypical). This was deemed necessary as standardisation would allow for later comparisons between mandibles.

Figure 4.1 – A mandible excluded on the grounds that it was not morphologically typical of an adult mandible.

Hemimandibles without examinable corresponding contralateral sides were excluded to allow for accurate determination of a possible preference of the RMF for a single side. It also allowed comparison between full mandibles rather than hemimandibles. Mandibles showing signs of pathology or other processes which may have influenced results (e.g. osteopetrosis, advanced alveolar bone resorption with loss of cortical bone in the retromolar area, etc.) and those where obvious signs of damage to the retromolar area, whether due to aging or handling of mandibles, were excluded.

A clearly identifiable cadaver number written on the mandible was necessary for inclusion. The inclusion of a mandible without a clear cadaver number would have resulted in the inability to correlate anatomical findings with demographic data.

A mandible was only included if both investigators deemed the specimen suitable after the application of the above criteria. If any differences of opinion were present after inspection of a certain mandible, the mandible in question was discussed until agreement between investigators was achieved. If no agreement was reached, the disputed mandible was excluded from the study.

4.1.2 Identification of the RMF

All mandibles deemed suitable for inclusion in the study population by application of the criteria outlined in 4.1.1 were inspected to determine the presence of the RMF. An identified foramen was only considered a confirmed RMF if it met the following criteria:

1. A visually perceptible foramen within the triangular area determined as the retromolar area, i.e. that area bounded by the external oblique ridge, the attachment of the buccinator muscle (the attachment of the pterygomandibular raphe, the so-called *internal oblique ridge*), and the distal surface of the ipsilateral M2 or M3 (see figure 4.2), whichever was

the most distally positioned mandibular molar (if no M2 or M3 was available, termination of the area was based on estimation of the position of the distal surface of the M2);

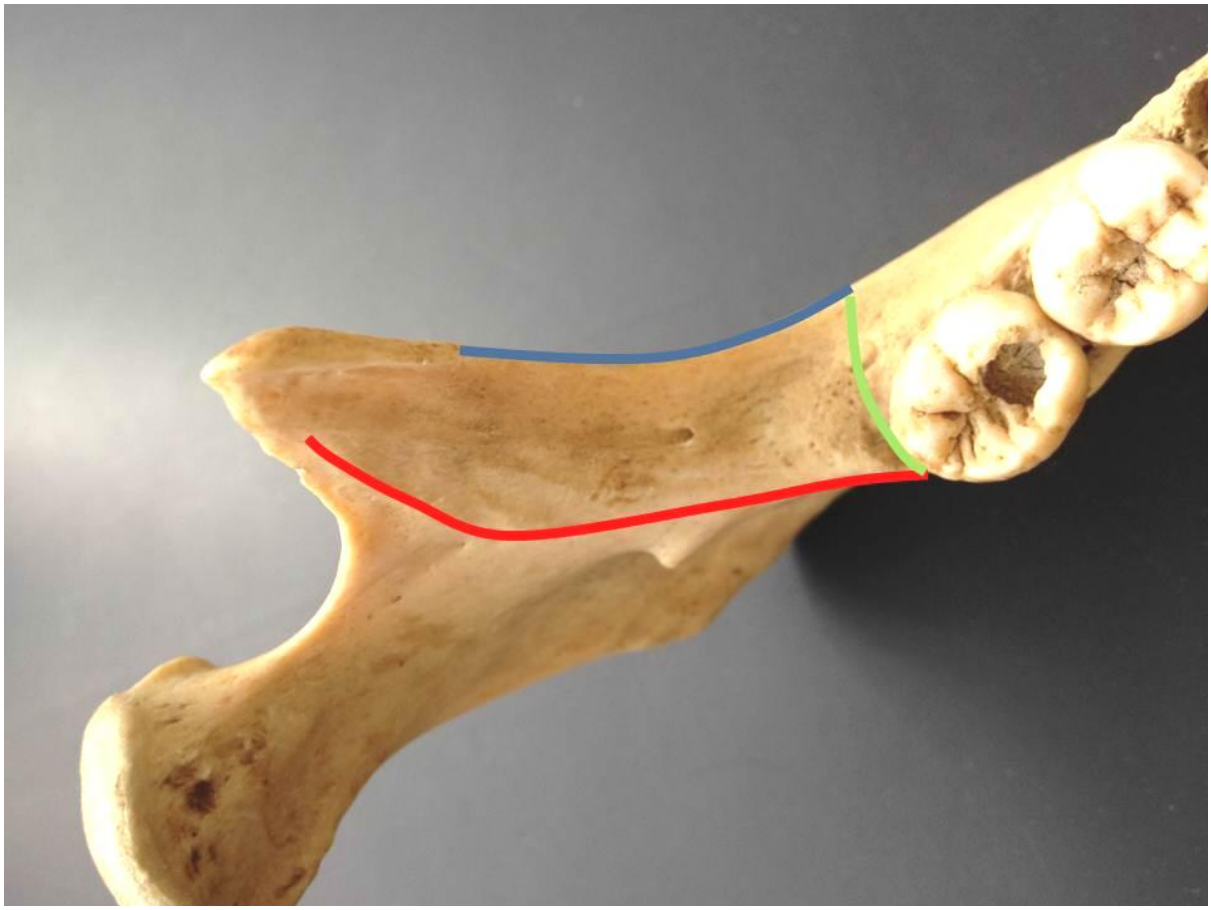

Figure 4.2 – Area defined as the 'retromolar area' in which the RMF occurred.

2. A foramen in which a non-bevelled needle with a diameter of 1 mm could be inserted without resistance (see figure 4.3).

If inspection of the retromolar area revealed a possible RMF but resistance to the introduction of a 1 mm needle was experienced, the RMF in the mandible in question was regarded as absent. No distinction was made between hemimandibles which contained one RMF and those which contained more than one RMF in the retromolar area. Whether single or multiple, the RMF was simply regarded as present.

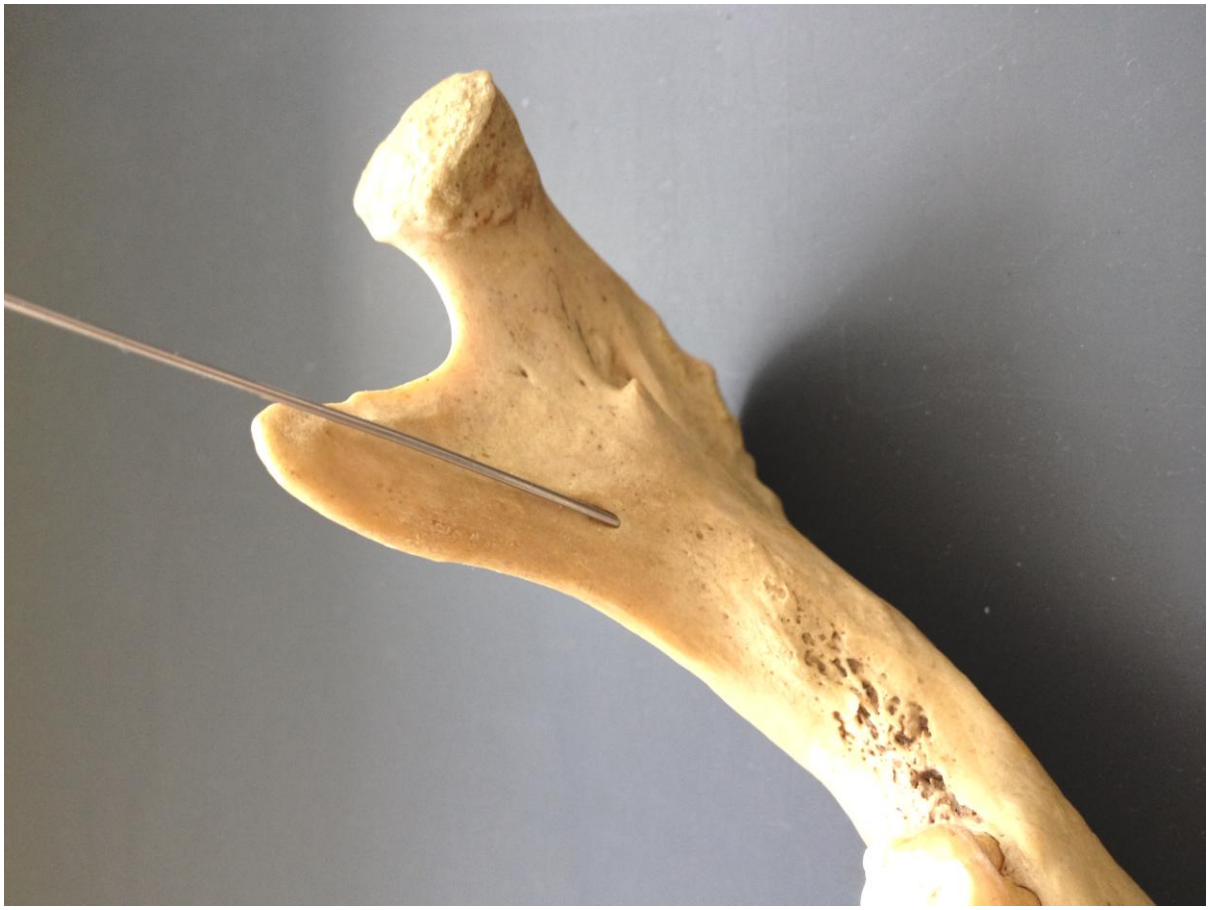

Figure 4.3 – Insertion of a 1 mm needle into the RMF without resistance.

4.1.3 Data collection

Data collection sheets were used to record the following variables: cadaver number, presence of the RMF, side of occurrence of the RMF (left, right or both sides), and distance from the RMF to the last mandibular molar (if an ipsilateral M2 or M3 was present). An example of the data collection sheet used can be seen in Appendix A.

High quality photographs of each specimen identified as having the RMF were taken. These included clear photographs of the cadaver number for later determination of demographic details available in the cadaver database of the Department of Anatomy.

In specimens with a confirmed RMF which had M2 or M3 as the last molar on the ipsilateral side, the shortest distance between the RMF and the last molar (whether M2 or M3) was determined with the use of a mechanical dial calliper (accuracy of 0.02 mm; see figure 4.4). Independent measurements were made by two different investigators. Measurements were then compared: If a discrepancy was found between the measurements of the two investigators the average of the two values was used.

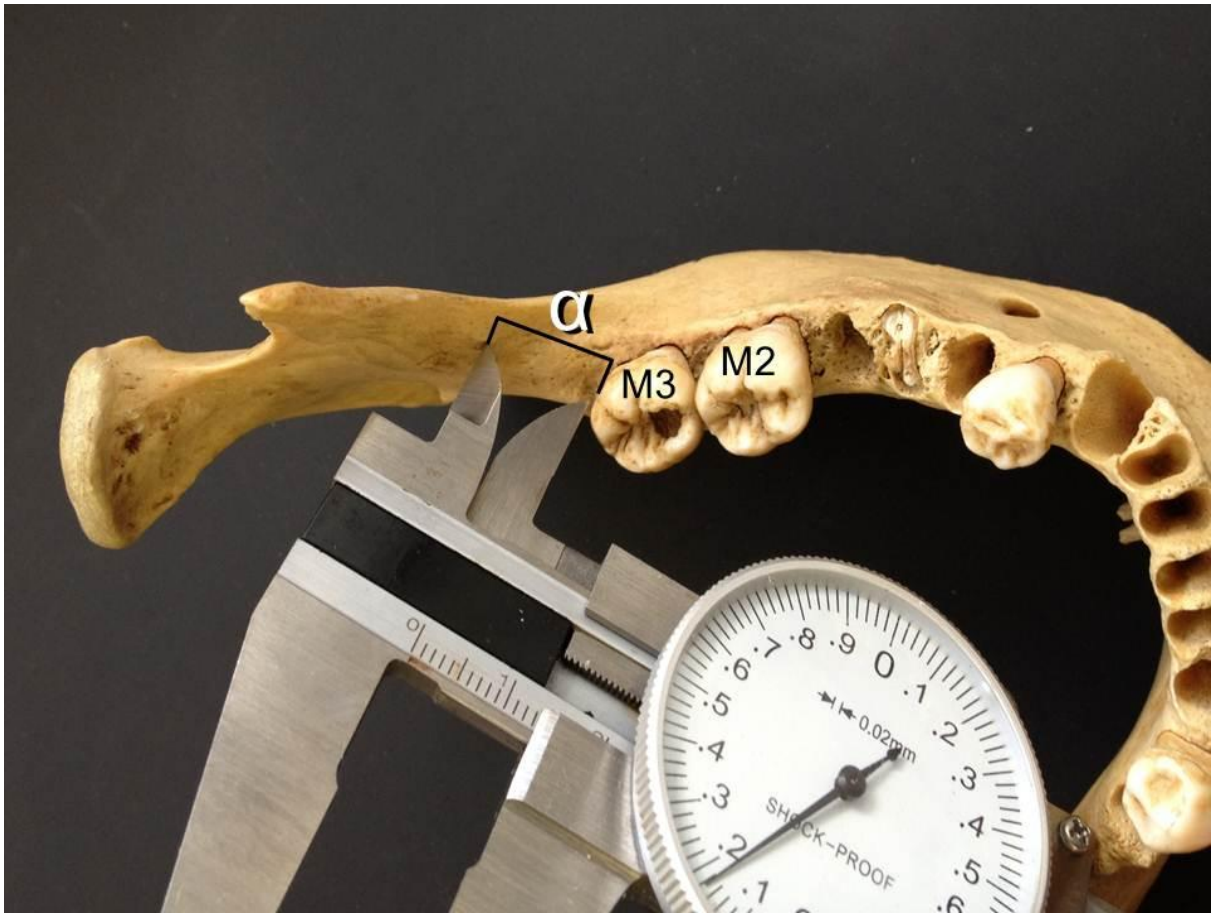

Figure 4.4 – Use of a mechanical dial calliper to determine the shortest distance from the last tooth to the RMF (distance denoted as α).

4.1.4 Correlation of collected data with the existing cadaver database

Collected data was correlated with the cadaver database. Data was entered into a Microsoft Excel spreadsheet. The spreadsheet layout allowed for capturing of the following information:

1. Cadaver number (numeric value);
2. Sex (male, female or unknown; unknown values represented by a question mark);
3. Age (numeric value or unknown; unknown values were represented by a question mark);
4. Identified racial grouping (black, white, coloured, other or unknown; unknown values were represented by a question mark);
5. Presence of RMF in the mandible (yes or no);
6. Presence of RMF on the left side (1 or 0; 1 if a foramen is present, 0 if it is not present);
7. Shortest distance between RMF on the left side and the left M3 (numeric value used if it was possible to determine a measureable value);
8. Shortest distance between RMF on the left side and the left M2 (numeric value used if it was possible to determine a measureable value);
9. Presence of RMF on the right side (1 or 0; 1 if a foramen is present, 0 if it is not present);

10. Shortest distance between RMF on the right side and the right M3 (numeric value used if it was possible to determine a measureable value);

11. Shortest distance between RMF on the right side and the right M2 (numeric value used if it was possible to determine a measureable value);

4.1.5 Definition of groups

Six defined groups were created to allow comparison between mandibles from different populations. Sex and race demographics were used to define these groups. These groups were:

1. All male;
2. All female;
3. Black male;
4. Black female;
5. White male;
6. White female.

All racial groupings other than those identified as black or white (i.e. those identified as coloured, other or unknown) were excluded due to difficulty in accurate identification or the presence of too few mandibles in these groups to consider them representative of the population groups they were derived from. All mandibles with unknown sex were also excluded.

The following information was obtained for each group from the raw data: prevalence of RMF, sidedness of RMF, average distance from RMF to the ipsilateral M2 or M3 where available, and distribution of the RMF across age groups.

4.2 Characterisation of the internal structure of the RMC using MicroCT

4.2.1 Acquisition of projections

Fifty pre-identified RMF (21 right, 29 left, see section 4.1) were selected at random (as outlined in section 4.2.4). The mandibles containing these RMF were scanned using the microfocus x-ray tomography unit (Nikon XTH 225 XT) at the MIXRAD facility at Necsa. These mandibles were scanned as part of the larger Pretoria-Pelindaba collection. Each scan contained two mandibles (see figure 4.5 for the orientation of mandibles during the scanning process). Mandibles were held in the desired orientation using floral foam (floral oasis, a radiolucent material). One mandible in the acquisition pair was clearly marked with 'Prestik' (Prestik was chosen due to its adhesive properties and a radiodensity clearly distinguishable from that of bone). Prestik was placed on one of the condyles of the selected mandible (an area convenient for identification but far enough from the region of interest to minimise scattering interference, i.e. the predetermined retromolar area and the inferior alveolar canal).

Figure 4.5 – Orientation of mandibles during the scanning process.

Scans were performed at a current of 70mA and a potential setting of 100kV. A total of 1000 projections were taken around a single axis of rotation with an exposure time of 0.5 seconds per projection. A total of 45 mandibles were included in the study due to bilateral presentation of the RMF in five mandibles.

4.2.2 Geometry processing, 3D reconstruction and data storage

Projections were encoded in the TIFF image file format. Creation of a 3D virtual volume from the 2D projections was performed using the CT-Pro software package (Nikon Metrology, Inc.). The filename of the resulting 3D scan included the cadaver numbers of both scans; the cadaver number of the mandible on which the Prestik was placed was preceded by the letter 'P' to avoid confusion. Scans were stored on an external hard drive. Redundancy of data was ensured by storage of the raw data on a local server at Necsa.

4.2.3 Analysis of scans

Virtual 3D tomograms of the scanned mandibles were analysed using the VGStudio MAX 2.2 (Volume Graphics GmbH) visualisation software package. The intra-osseous course of canals communicating with an identified RMF was traced. Traced canals were viewed from their buccal (lateral) aspect. Comparisons with existing classification schemes formulated for the RMC based on the work of Ossenberg (2), Narayana *et al*. (18) and von Arx *et al*. (7, 21) was made.

4.2.4 Random selection of scanned RMF

Random selection of scanned RMF was performed computationally. The cadaver numbers of all RMF were placed in order of ascending number in a text file with each

number written on a new line. The letters R (for right) or L (for left) were appended to the cadaver number to identify the side of the mandible the RMF appeared on, avoiding confusion in cases where a single mandible had bilateral RMCs.

Eighty-two RMF were identified. Their cadaver numbers were written into a text file as described above. A computer programme was written in the Python programming language for the purpose of random selection of the RMF (see Appendix B for the code). The programme was used to read the values in the text file and associated each value with a pseudo-random number (numbers generated in this way are based on the system clock of a computer and are essentially random) between 0 and 999 999.

Non-repeating pseudo-random numbers between 0 and 999 999 were then generated. When these numbers matched the pseudo-random number associated with an identified RMF, the cadaver number of that mandible along with its side was written to an output text file. This process continued until 50 RMF were selected (see Appendix C for the selected RMF). The mandibles containing these 50 RMF were then scanned.

4.3 Compilation of a guideline for the management of the RMF in clinical dentistry

The results of sections 4.1 and 4.2, literature review and anatomical study were used to compile a working guideline for dentists. This guideline was produced with the aim to:

1. avoid possible complications associated with the presence of the RMF by producing a description of the relevant anatomy, discussing local anaesthetic technique and suggesting possible alterations to surgical technique;
2. advise on techniques to reduce and manage potential complications associated with the presence of the RMF.

The literature review consisted mostly of articles identified through a search of the PubMed database. As very few articles on the RMF were available at the time of writing, a search for the keywords ‘retromolar foramen’ was used without further modification or application of filters. Articles were then sorted by title and abstract (included or excluded based on relevance to the RMF). The University of Pretoria’s online journal database and other online and print-based repositories were then searched for availability of identified articles. Articles were included based on the relevancy of their content. These articles were supplemented with books and other sources.

Literature on local anaesthetic failure and technique, surgical methods and complications in dental surgery was also consulted. Similar methods as described above were used.

The anatomical study mostly consisted of that outlined in sections 4.1 and 4.2. Measurement of the position of the RMF in relation to M2 and M3 and the orientation

of the contents of the RMC as they escaped the canal into the soft tissues based on described clinical details and photographs were considered the most easily identifiable indicators of risk to these structures. Few reports of the risks associated with the presence of the RMF and their management were available, necessitating the prescription of techniques described to manage apparently similar problems.

The guide will serve to reduce possible anxiety related to the discovery of this relatively unknown anatomical variation and improve surgical outcomes. Its desired effect is to improve surgical confidence, especially in those inexperienced in oral surgery, with the aim to improve the experience of oral health provision for both patient and practitioner.

5. RESULTS

5.1 Prevalence and distribution of the RMF in the South African population

5.1.1 Prevalence of the RMF in the total sample

A total number of 946 mandibles were inspected. Before correlation with demographic data, 933 of these mandibles were judged suitable for inclusion on inspection alone.

A further 48 mandibles were excluded after correlation of cadaver numbers with data in the cadaver database of the University of Pretoria's Department of Anatomy. Twenty-one of these mandibles were listed as belonging to a race group called 'other'. Five mandibles belonged to the coloured racial grouping (excluded on the basis that the number was too small to be representative of the group of individuals who identify themselves as belonging to the coloured racial group in South Africa). The remaining 27 mandibles were excluded on the basis of incomplete demographic data.

A total of 885 mandibles were included in the study. Of these 885 mandibles, 710 were male (80.2%) and 175 were female (19.8%). Age ranged between 12 and 98 (see figures 5.1, 5.2 and 5.3 for age distribution of the total sample mandibles). A mean age of 59.0 years, a median of 60 years and a mode of 60 years was seen in the total sample. Seventy mandibles had at least one RMF present (prevalence of 7.9% of mandibles in the total sample), of which 43 had at least one RMF on the left side (61.4% of total mandibles presenting with the RMF had at least one RMF on the left side) and 39 had at least one RMF on the right side (55.7% of total mandibles presenting with the RMF had at least one RMF on the right side). The RMF was found bilaterally in 12 mandibles (17.1%). Table 5.1 shows the prevalence of the

RMF in the study population. A full list of all included mandibles is available in Appendix D.

Table 5.1 – Prevalence of the RMF in the total population

	n	YES	NO	%
TOTAL SAMPLE	885	70	815	7.9
PRESENT:				
LEFT	70	43	-	61.4
RIGHT	70	39	-	55.7
BILATERAL	70	12	-	17.1

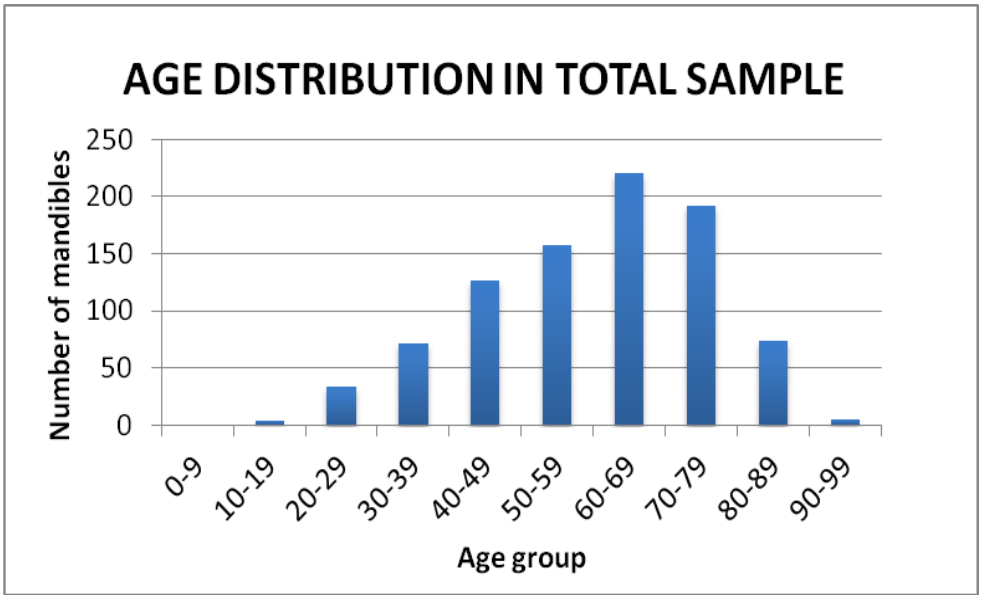

Figure 5.1 – Age distribution of mandibles in the total sample.

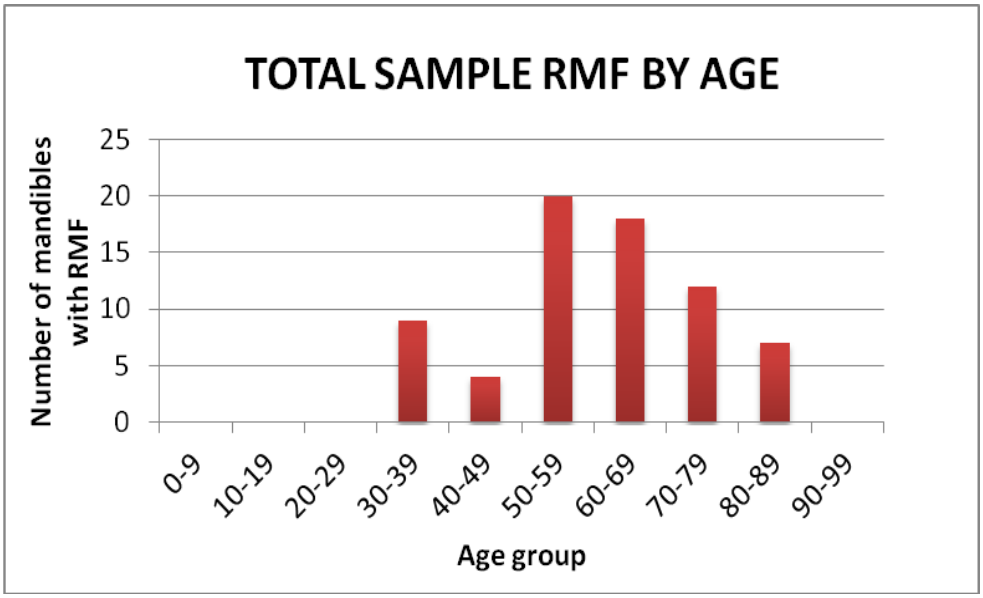

Figure 5.2 – Age distribution of the RMF in the total sample.

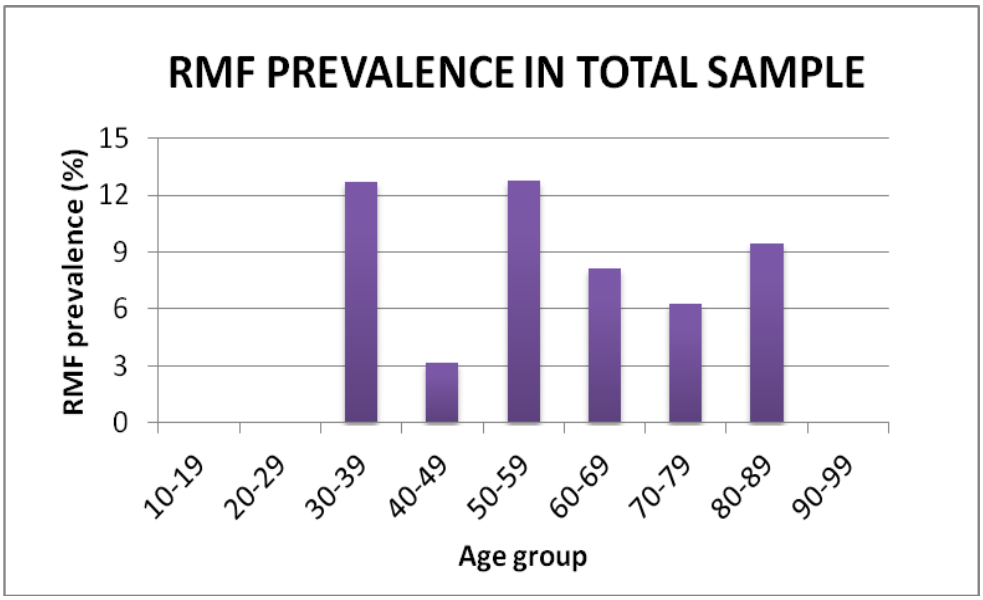

Figure 5.3 – Prevalence of the RMF across age groups.

5.1.2 Prevalence of the RMF in predetermined groups

Group 1 consisted of all mandibles in the total sample identified as male. These mandibles numbered 710. Age ranged between 12 and 98, with a mean of 58.2

years, and a median and mode of 60 years (see figures 5.4, 5.5 and 5.6 for age distribution of group 1 mandibles and RMF). Fifty-seven mandibles showed at least one RMF (prevalence of 8.0% of group 1 mandibles). Thirty-four RMF were found on the left (59.6% of group 1 mandibles with RMF had at least one RMF on the left side) and 34 were found on the right (59.6% of group 1 mandibles with RMF had at least one RMF on the right side). Eleven mandibles had RMF bilaterally (19.3% of group 1 mandibles with RMF had them bilaterally). Table 5.2 shows the prevalence of the RMF in group 1.

Table 5.2 – Prevalence of the RMF in group 1 mandibles

	n	YES	NO	%
INCLUDED MALES	710	57	653	8.0
PRESENT:				
LEFT	57	34	-	59.6
RIGHT	57	34	-	59.6
BILATERAL	57	11	-	19.3

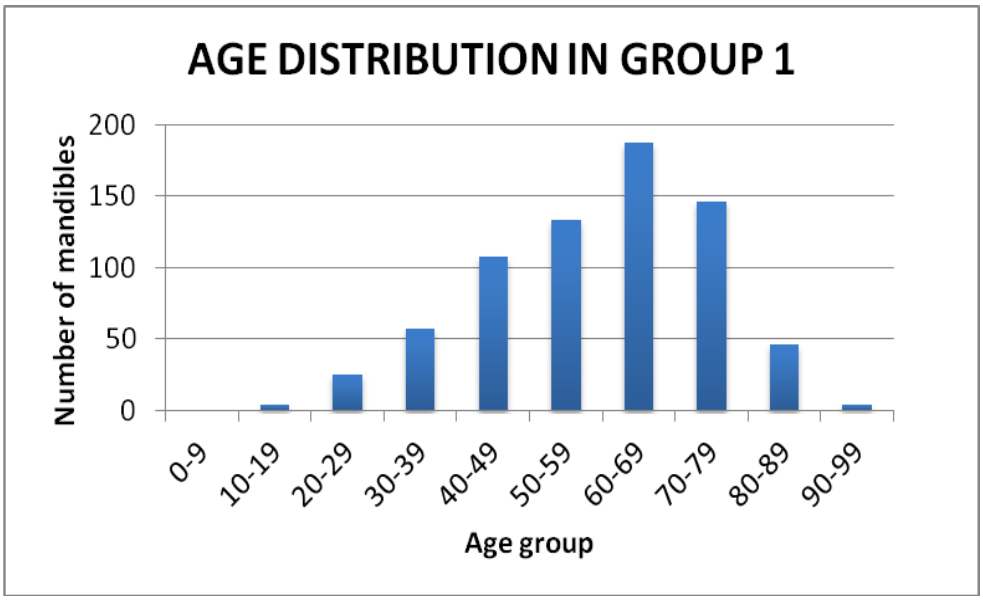

Figure 5.4 – Age distribution of mandibles in group 1.

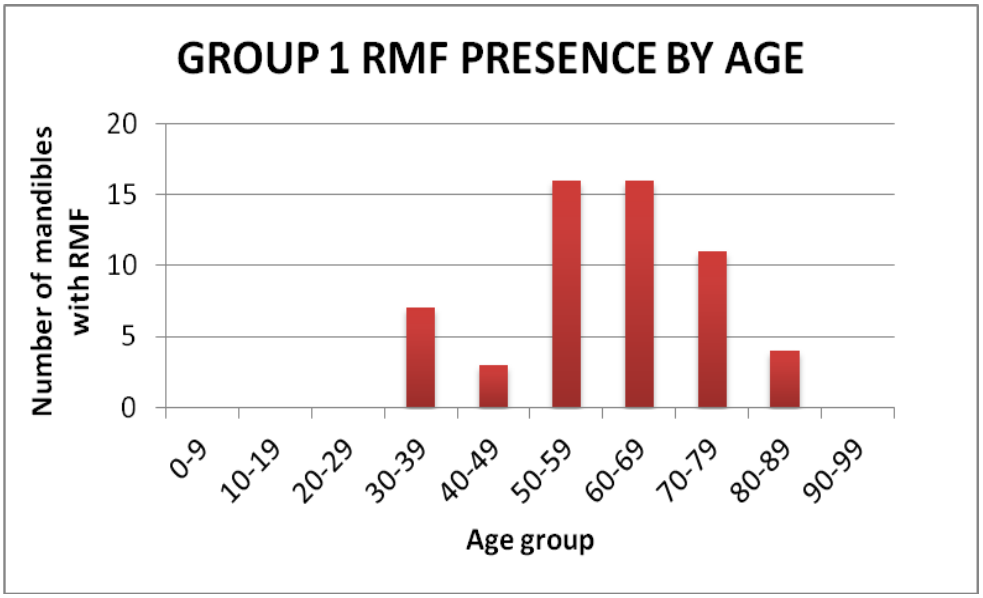

Figure 5.5 – Age distribution of RMF in group 1 mandibles.

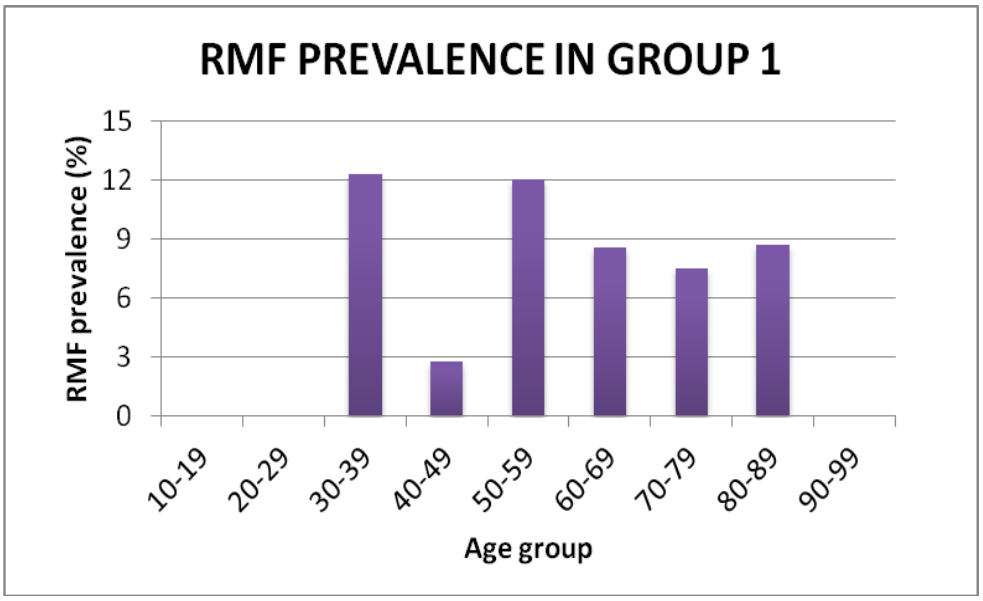

Figure 5.6 – RMF prevalence in group 1 mandibles.

Group 2 consisted of all mandibles in the total sample identified as female. These mandibles numbered 175. Age ranged between 21 and 90, with a mean of 62.2 years, a median of 65 years and mode of 74 years (see figures 5.7, 5.8 and 5.9 for age distribution of group 2 mandibles and RMF). Thirteen mandibles showed at least

one RMF (prevalence of 7.4% of group 2 mandibles). Nine RMF were found on the left (69.2% of group 2 mandibles had at least one RMF on the left side) and five were found on the right (38.5% of group 2 mandibles with RMF had at least one RMF on the right side). One mandible had bilateral RMF (7.7% of group 2 mandibles with RMF had them bilaterally). Table 5.3 shows the prevalence of the RMF in group 2.

Table 5.3 – Prevalence of the RMF in group 2 mandibles

	n	YES	NO	%
INCLUDED FEMALE	175	13	162	7.4
PRESENT:				
LEFT	13	9	-	69.2
RIGHT	13	5	-	38.5
BILATERAL	13	1	-	7.7

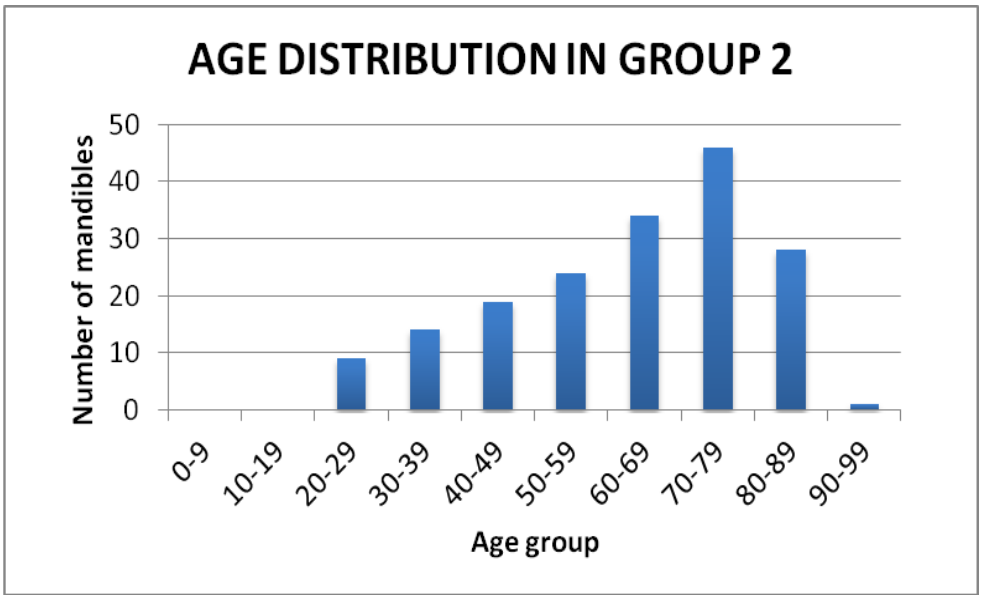

Figure 5.7 – Age distribution of mandibles in group 2.

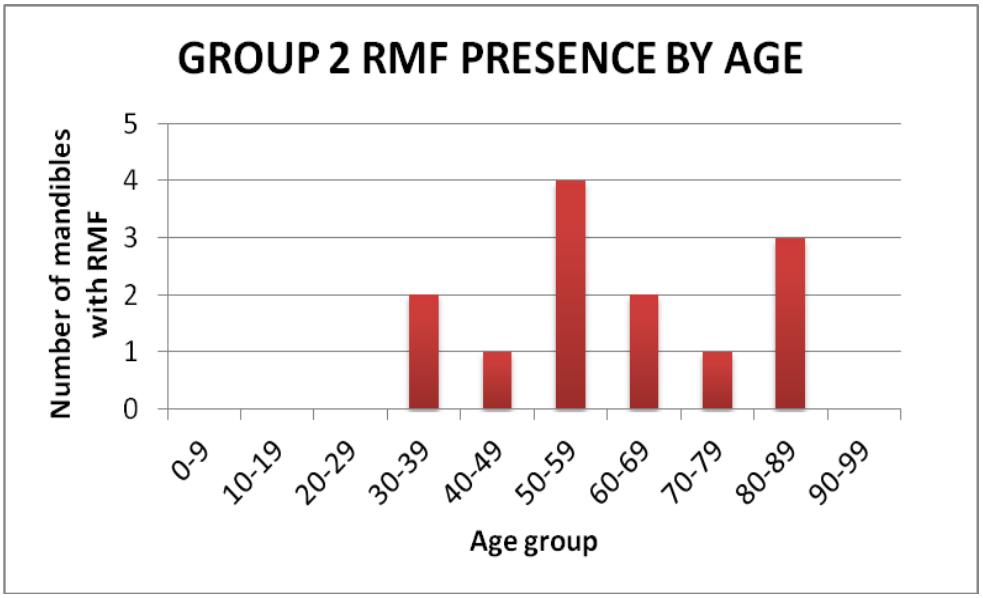

Figure 5.8 – Age distribution of RMF in group 2 mandibles.

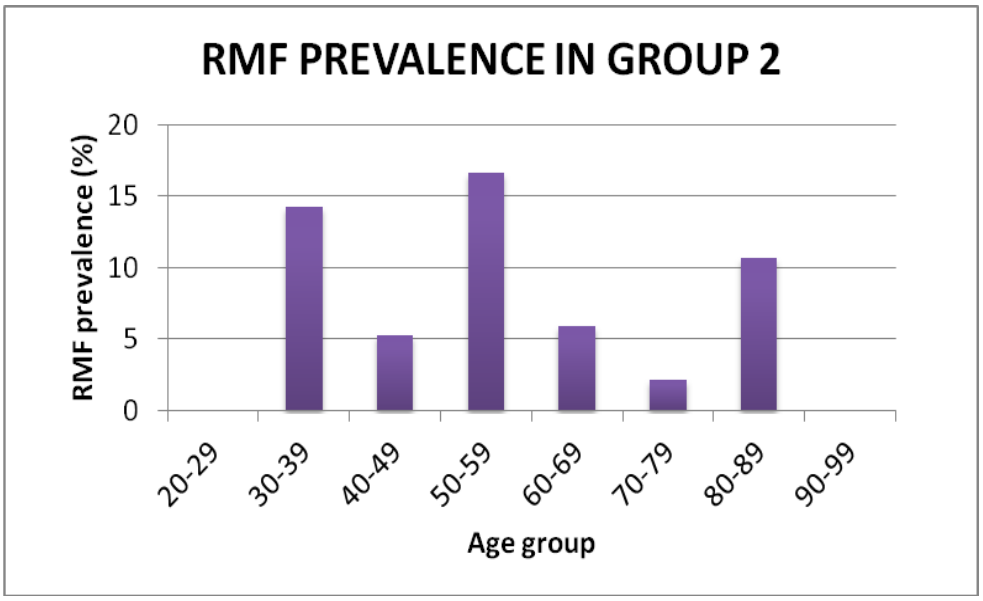

Figure 5.9 – RMF prevalence in group 2 mandibles.

Group 3 consisted of all mandibles in the total sample identified as black male. These mandibles numbered 554. Age ranged between 12 and 98, with a mean of 55.0 years, a median of 57 years and mode of 60 years (see figures 5.10, 5.11 and 5.12 for age distribution of group 3 mandibles and RMF). Forty-three mandibles

showed at least one RMF (prevalence of 7.8% of group 3 mandibles). Twenty-seven RMF were found on the left (62.8% of group 3 mandibles with RMF had at least one RMF on the left side) and 24 were found on the right (55.8% of group 3 mandibles with RMF had at least one RMF on the right side). Eight mandibles had bilateral RMF (18.6% of group 3 mandibles with RMF had them bilaterally). Table 5.4 shows the prevalence of the RMF in group 3.

Table 5.4 – Prevalence of the RMF in group 3 mandibles

	n	YES	NO	%
BLACK MALE	554	43	511	7.8
PRESENT:				
LEFT	43	27	-	62.8
RIGHT	43	24	-	55.8
BILATERAL	43	8	-	18.6

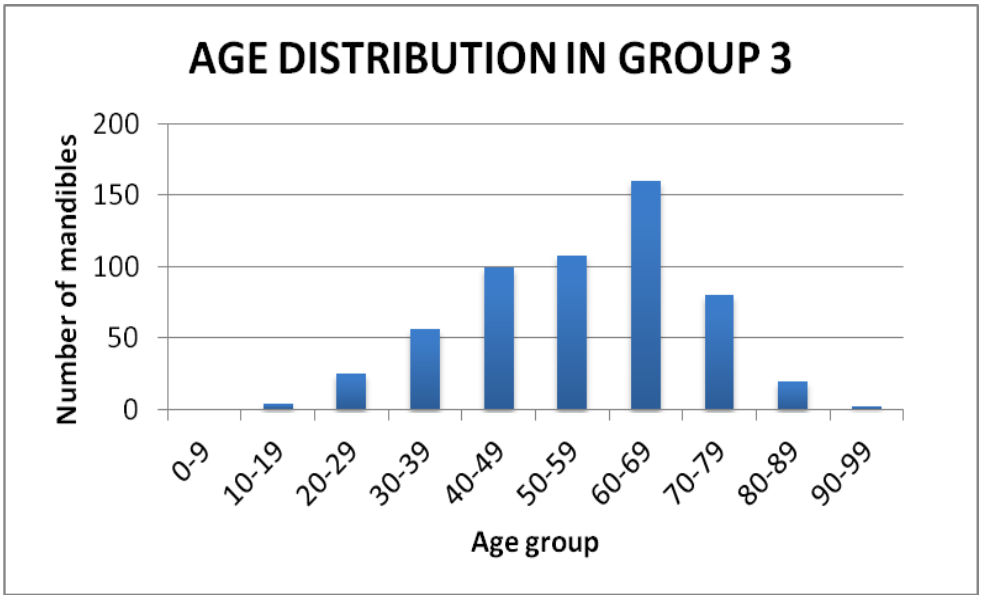

Figure 5.10 – Age distribution of mandibles in group 3.

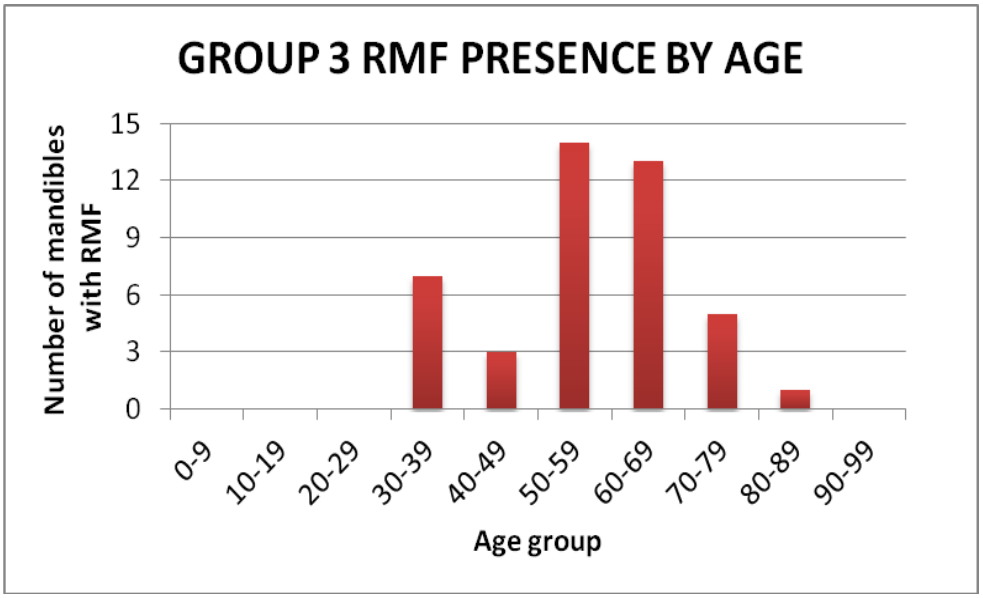

Figure 5.11 – Age distribution of RMF in group 3 mandibles.

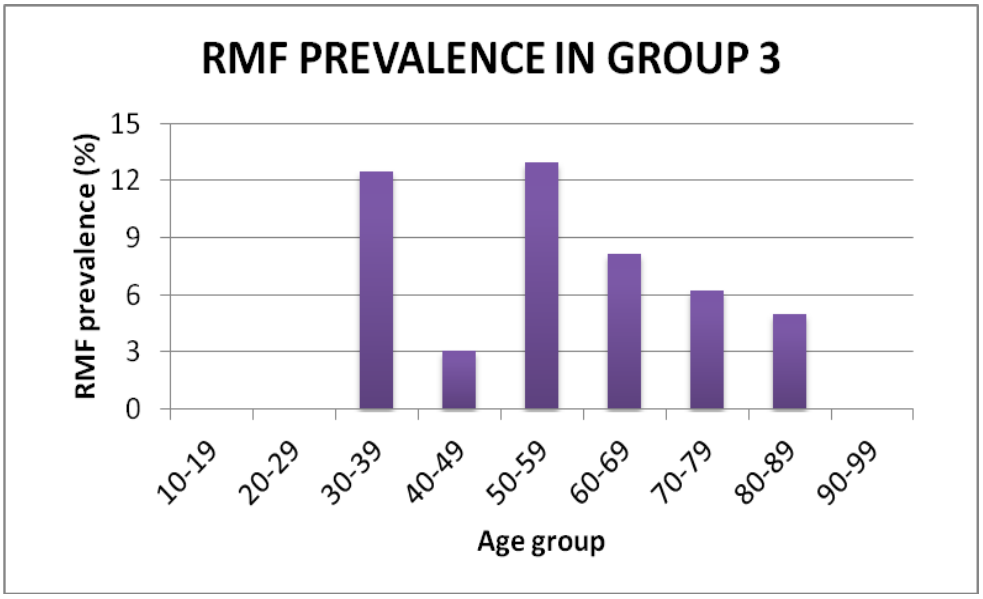

Figure 5.12 – RMF prevalence in group 3 mandibles.

Group 4 consisted of all mandibles in the total sample identified as black female. These mandibles numbered 74. Age ranged between 21 and 80, with a mean of 48.9 years, a median of 48.5 years and mode of 60 years (see figures 5.13, 5.14 and 5.15

for age distribution of group 4 mandibles and RMF). Six mandibles showed at least one RMF (prevalence of 8.1% of group 4 mandibles). Three RMF were found on the left (50.0% of group 4 mandibles with RMF had at least one RMF on the left side) and four were found on the right (66.7% of group 4 mandibles with RMF had at least one RMF on the right side). One mandible had bilateral RMF (16.7% of group 4 mandibles with RMF had them bilaterally). Table 5.5 shows the prevalence of the RMF in group 4.

Table 5.5 – Prevalence of the RMF in group 4 mandibles

	n	YES	NO	%
BLACK FEMALE	74	6	68	8.1
PRESENT:				
LEFT	6	3	-	50.0
RIGHT	6	4	-	66.7
BILATERAL	6	1	-	16.7

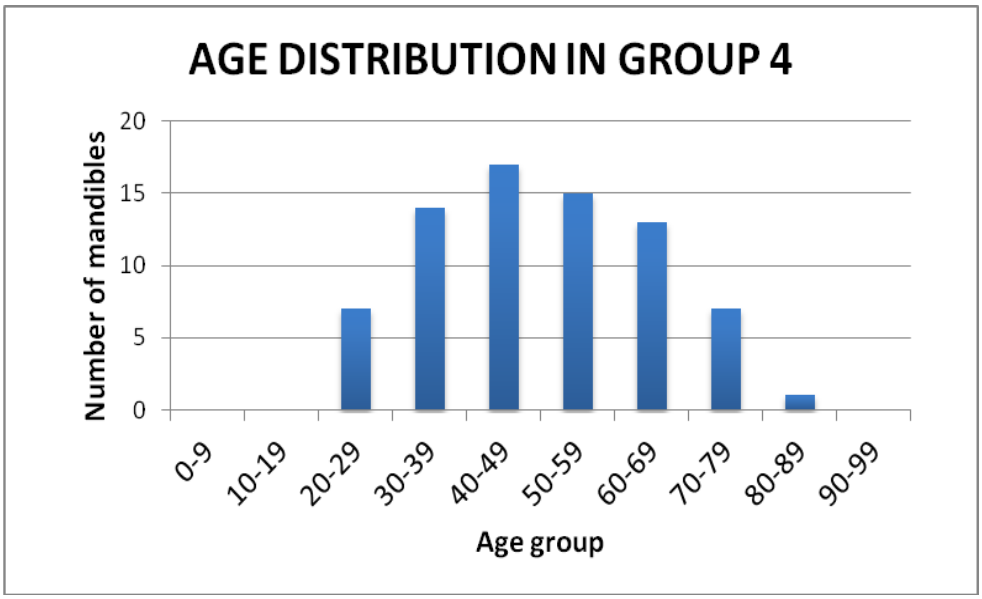

Figure 5.13 – Age distribution of mandibles in group 4

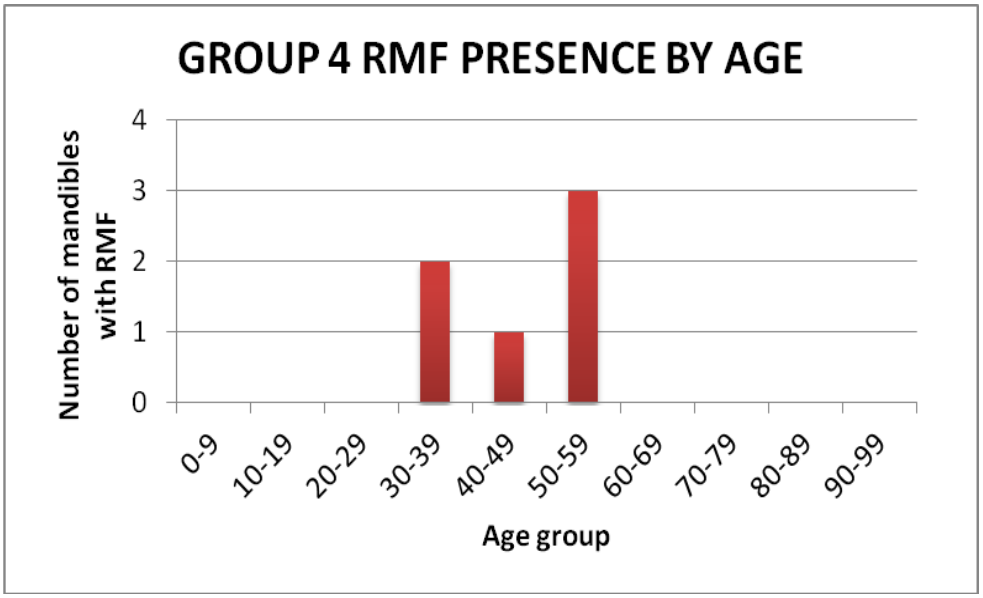

Figure 5.14 – Age distribution of RMF in group 4 mandibles.

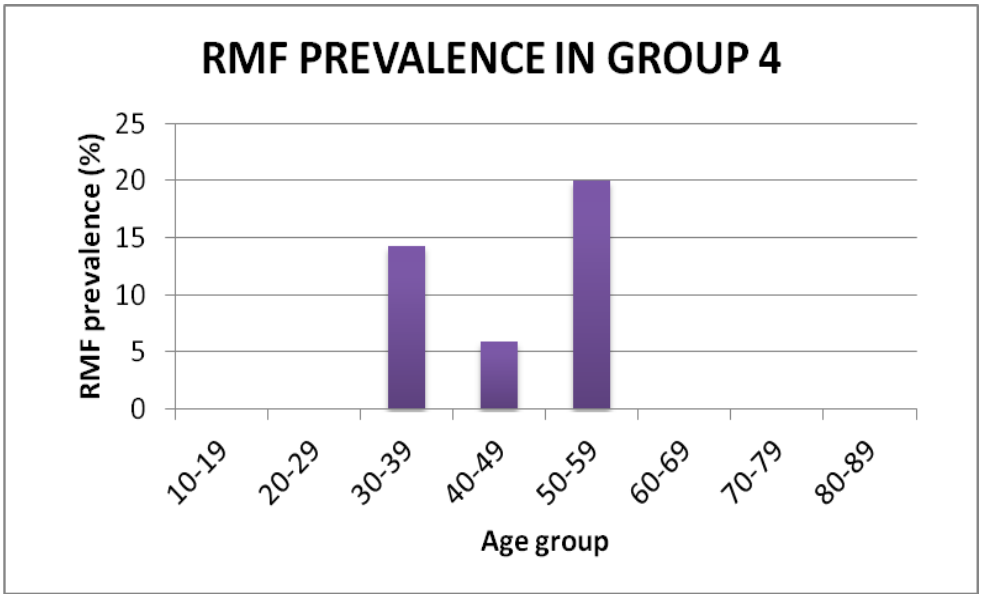

Figure 5.15 – RMF prevalence in group 4 mandibles.

Group 5 consisted of all mandibles in the total sample identified as white male. These mandibles numbered 156. Age ranged between 36 and 91, with a mean of 69.4 years, a median of 72 and mode of 77 years (see figures 5.16, 5.17 and 5.18 for age distribution of group 5 mandibles and RMF). Fourteen mandibles showed at

least one RMF (prevalence of 9.0% of group 5 mandibles). Seven RMF were found on the left (50.0% of group 5 mandibles with RMF had at least one RMF on the left side) and 10 were found on the right (71.4% of group 5 mandibles with RMF had at least one RMF on the right side). Three mandibles had bilateral RMF (21.4% of group 5 mandibles with RMF had them bilaterally). Table 5.6 shows the prevalence of the RMF in group 5.

Table 5.6 – Prevalence of the RMF in group 5 mandibles

	n	YES	NO	%
WHITE MALE	156	14	142	9.0
PRESENT:				
LEFT	14	7	-	50.0
RIGHT	14	10	-	71.4
BILATERAL	14	3	-	21.4

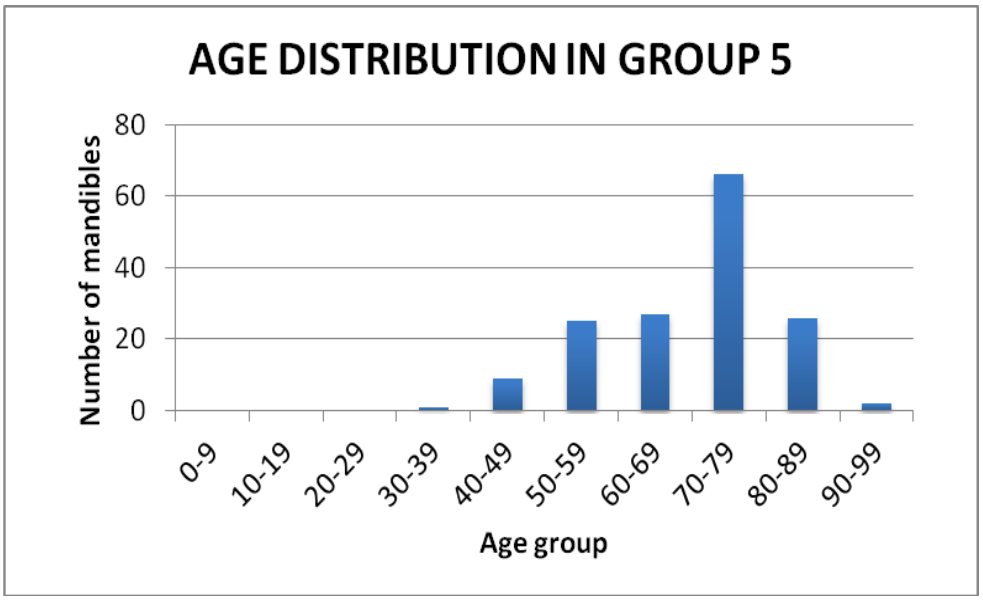

Figure 5.16 – Age distribution of mandibles in group 5.

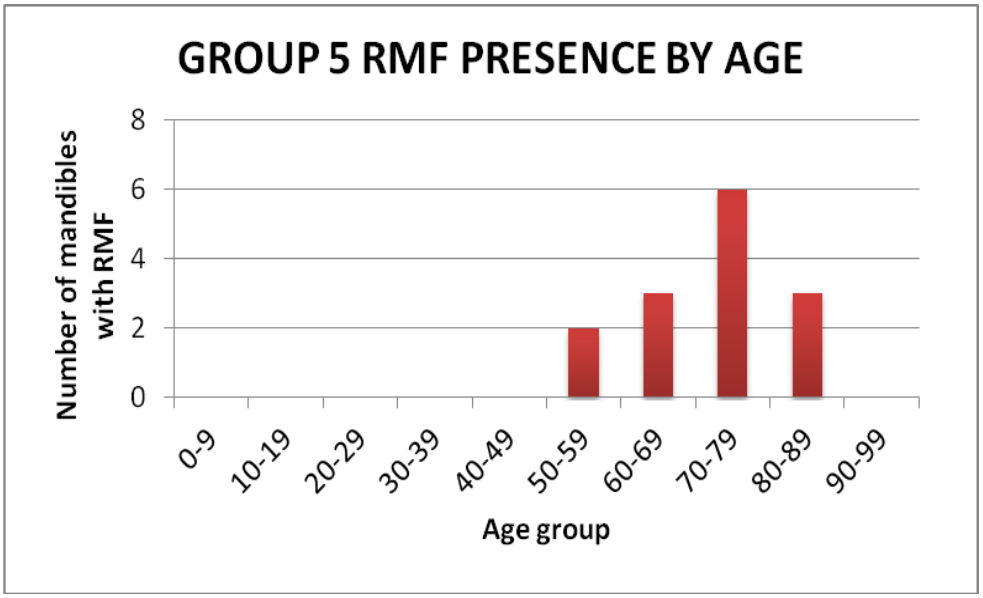

Figure 5.17 – Age distribution of RMF in group 5 mandibles.

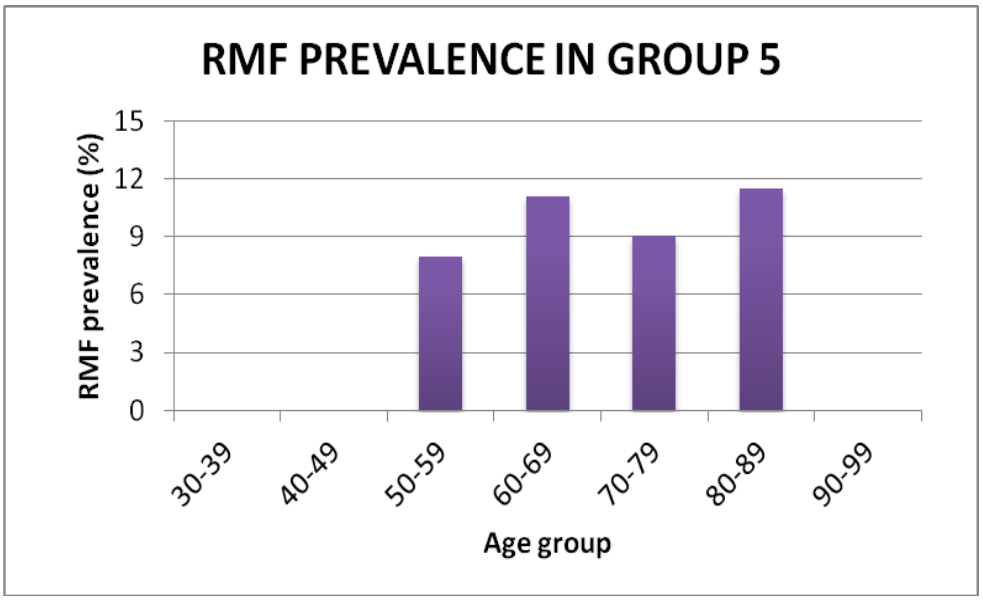

Figure 5.18 – RMF prevalence in group 5 mandibles.

Group 6 consisted of all mandibles in the total sample identified as white female. These mandibles numbered 101. Age ranged between 21 and 90, with a mean of 71.9 years, a median and mode of 74 years (see figures 5.19, 5.20 and 5.21 for age distribution of group 6 mandibles and RMF). Seven mandibles showed at least one

RMF (prevalence of 6.9% of group 6 mandibles). Six RMF were found on the left (85.7% of group 6 mandibles with RMF had at least one RMF on the left side) and one was found on the right (14.3% of group 5 mandibles with RMF had at least one RMF on the right side). No mandibles with bilateral RMF were found in this group. Table 5.7 shows the prevalence of the RMF in group 6.

Table 5.7 – Prevalence of the RMF in group 6 mandibles

	n	YES	NO	%
WHITE FEMALE	101	7	94	6.9
PRESENT:				
LEFT	7	6	-	85.7
RIGHT	7	1	-	14.3
BILATERAL	7	0	-	0.0

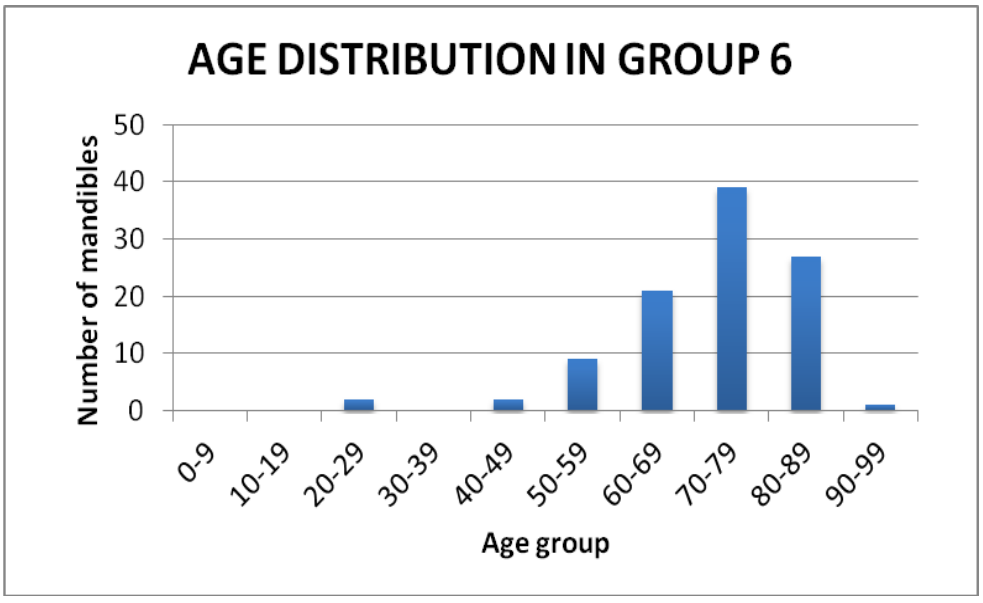

Figure 5.19 – Age distribution of mandibles in group 6.

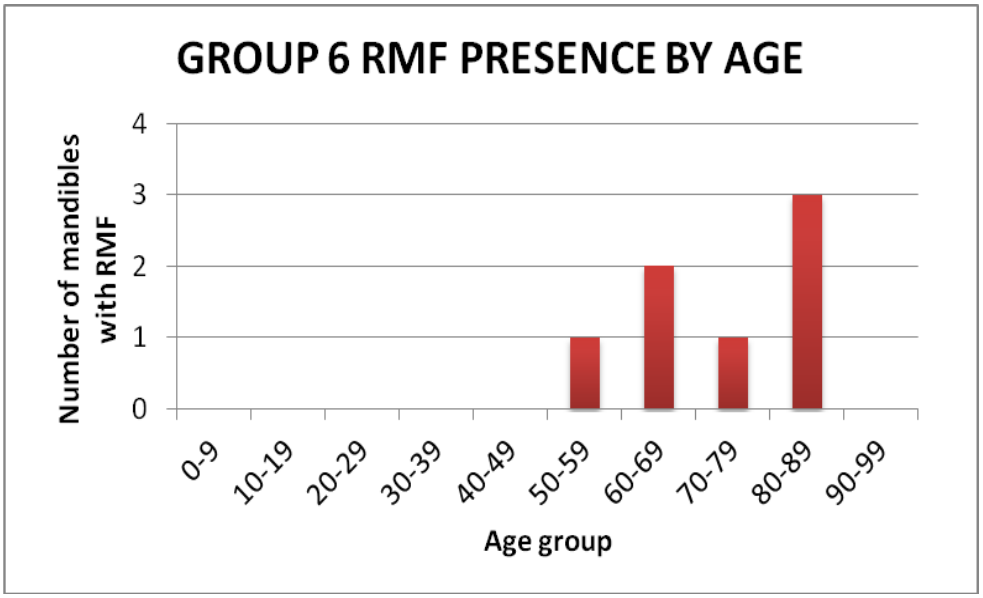

Figure 5.20 – Age distribution of RMF in group 6 mandibles.

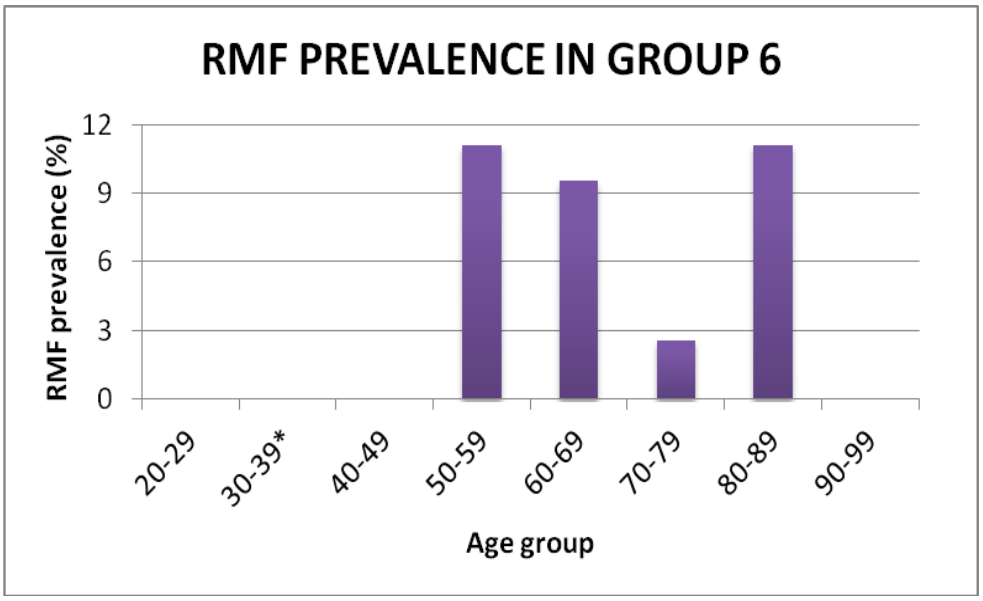

Figure 5.21 – RMF prevalence in group 6 mandibles.

5.1.3 Distance from the RMF to the last mandibular molar

Distances from last remaining mandibular molar to the RMF were recorded without respect to grouping, i.e. no division between groupings based on sex or race was made. Only distances from M2 or M3 to the RMF on the ipsilateral side were measured. No measurements were made if these teeth were not present.

Eight left hemimandibles with RMF and M2 as the last tooth were included in the sample. The smallest distance between the RMF and M2 was 11.99 mm and the largest distance was 19.00 mm. The average distance was 17.13 ± 6.14 mm with a median distance of 14.62 mm.

Sixteen left hemimandibles with RMF and M3 as the last tooth were included in the sample. The smallest distance between the RMF and M3 was 4.76 mm and the largest distance was 21.01 mm. The average distance was 11.07 ± 4.32 mm with a median distance of 11.18 mm.

Four right hemimandibles with RMF and M2 as the last tooth were included in the sample. The smallest distance between the RMF and M2 was 8.78 mm and the largest distance was 19.24 mm. The average distance was 16.22 ± 5.01 mm with a median distance of 18.43 mm.

Eighteen right hemimandibles with RMF and M3 as the last tooth were included in the sample. The smallest distance between the RMF and M3 was 5.15 mm and the largest distance was 16.42 mm. The average distance was 9.94 ± 3.23 mm with a median distance of 9.97 mm. Table 5.8 shows the combined values of right and left M2 and M3 distances from the RMF.

Table 5.8 – Average distance from last molar (combined left and right)

	SECOND MOLAR (mm)	THIRD MOLAR (mm)
n	12	34
MEAN	16.83	10.47
MEDIAN	16.85	10.14
STDEV	± 5.57	± 3.77

5.2 Characterisation of the internal structure of the RMC using MicroCT

Microtomographic analysis of 50 RMCs revealed the internal structure of canals associated with foramina identified as RMF in section 5.1. The findings were categorised according to the scheme used by von Arx *et al*. (21) to present variations found in their study. Figure 5.22 shows MicroCT projections of variations corresponding to those found by von Arx *et al*. obtained in the present study. The TCC described by Ossenberg (2) was also included.

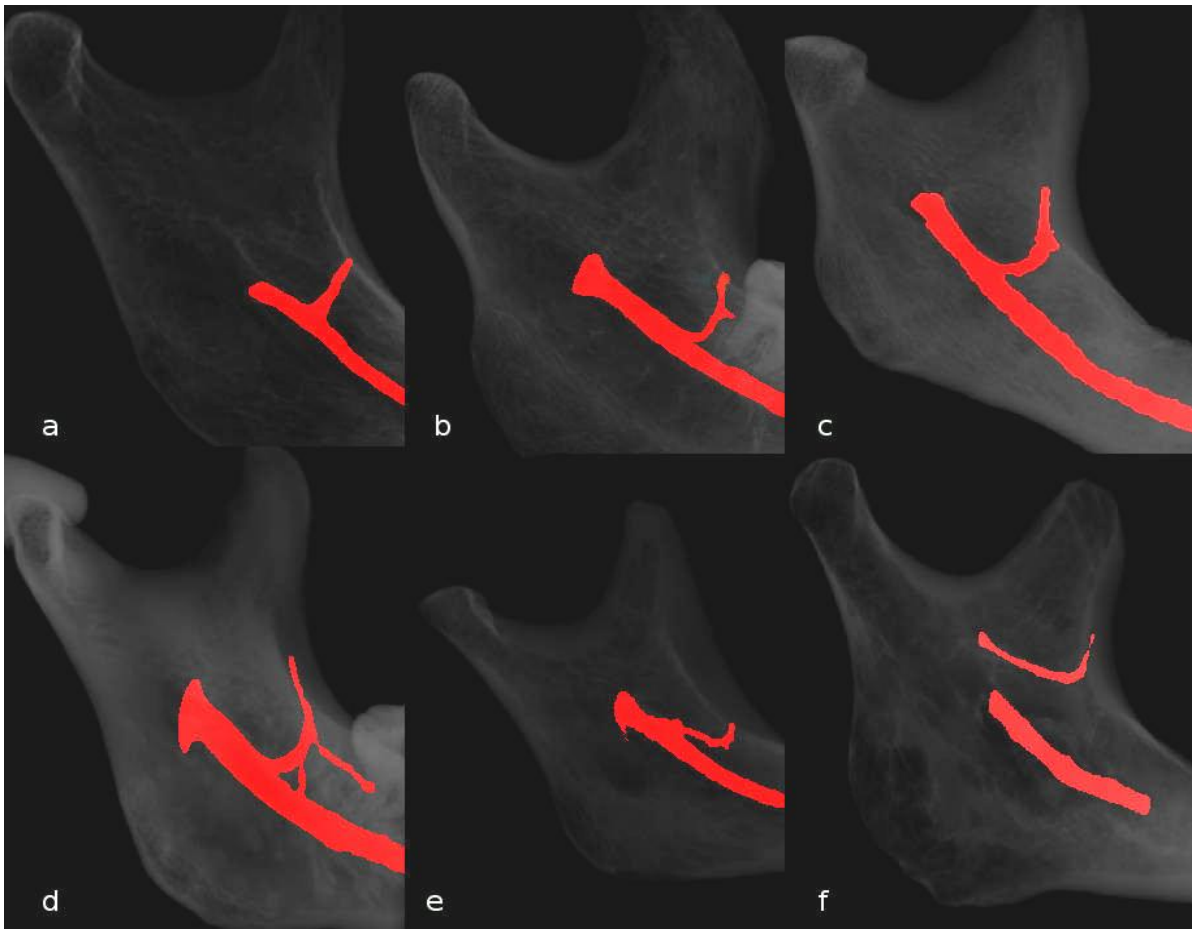

Figure 5.22 – Variations of canals associated with foramina identified as RMF. (a – Type A1; b – Type A2; c – Type B1; d – Type B2; e – Type C; f – TCC)

Type A1, a single canal projecting vertically from the inferior alveolar canal (showing no branches projecting anteriorly), was detected in five out of 50 RMCs (10%). Type A2, following a pattern similar to type A1 but with a branch of the canal projecting in an anterior direction (towards the region of the last molar), was detected in one out of 50 RMCs (2%). A total of six RMCs were considered representative of 'A-type' canals (12%).

Type B1, a single canal leaving the inferior alveolar canal along a course curved in a posterior and superior direction (showing no branches projecting anteriorly), was detected in 26 out of 50 RMCs (52%). Type B2, following a pattern similar to type B1 but with a branch of the canal projecting in an anterior direction (towards the last molar), was detected in eight out of 50 RMCs (16%). A total of 34 RMCs were considered representative of 'B-type' canals (68%).

Type C, a canal leaving the inferior alveolar canal and following a course which is approximately horizontal (assuming the lower border of the mandible defines a horizontal plane), was detected in two out of 50 RMCs (4%).

Along with canals which could be described as fitting into this scheme, two other groups were found. Those analogous to the temporal crest canal (TCC) described by Ossenberg (2, 10), and those which did not fit any category described ('new' variations, see figure 5.23). The TCC group made up 2 of the 50 identified canals (4%). New variations made up 6 of the 50 scanned canals (12%). Table 5.9 shows all variations detected in the sample.

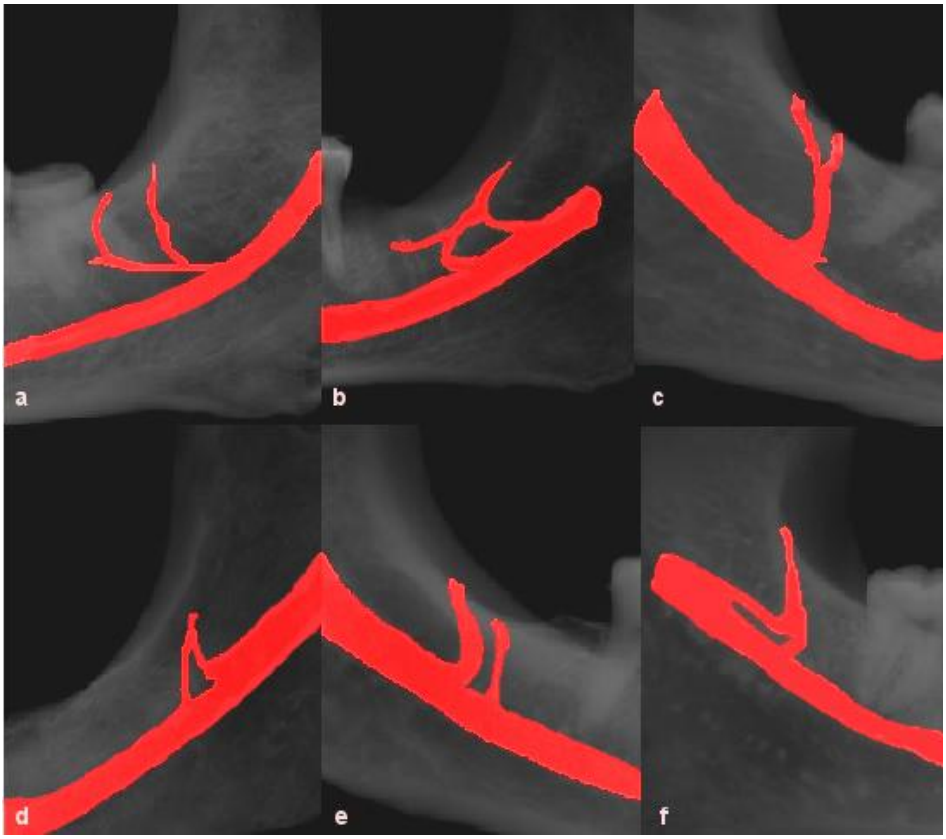

Figure 5.23 – Variations of RMC which do not belong to any category.

Table 5.9 – All scanned RMCs

VARIATION	NUMBER PRESENT	PERCENT (%)
A1	5	10
A2	1	2
B1	26	52
B2	8	16
C	2	4
TCC	2	4
NEW	6	12
TOTAL	50	100

5.3 Compilation of a guideline for the management of the RMF in clinical dentistry

A clinical guideline will be presented as part of the 'discussion' section of this work (see section 6.3). All results obtained in sections 5.1 and 5.2 were considered. The guide may be considered suitable for inclusion in the results segment of this work, but it can only be appreciated to its full extent after interpretation of results of sections 5.1 and 5.2 (see 'Discussion' sections 6.1 and 6.2).

6. DISCUSSION

6.1 Prevalence and distribution of the RMF in the South African population

6.1.1 Prevalence of the RMF

Results show that 7.9% of South Africans have at least one RMF (combined black male, white male, black female and white female – too few skeletal samples of other groups were available to be included in this study). Statistical analysis in the form of an odds ratio determined that not one single variable deemed important in the study, i.e. sex, race or age, increased the likelihood of the presence of the RMF in a single mandible (see table 6.1). This finding is significant – it suggests that all South African patients treated by dentists and dental specialists should be regarded as having the same likelihood of having the RMF. The same precautionary measures should be applied to all patients regardless of sex, race or age.

Table 6.1 – Odds ratio estimates of the effect of sex, race and age on the probability of the RMF appearing in a single mandible

VARIABLE	POINT ESTIMATE *	95% WALD CONFIDENCE LIMITS	
SEX	0.9	0.465	1.743
RACE	0.996	0.531	1.869
AGE	1.005	0.987	1.023

*a point estimate of greater than 0.05 indicates no statistically significant effect of a single variable on probability of the presence of the RMF

The prevalence of the RMF in previously studied populations ranged between a high of 72% in Argentine aborigines studied by Schejtman *et al.* (13) to a low of 0% in the

black African (i.e. black population on the African continent) skeletal samples studied by Ossenberg. (2) The RMF prevalence found in the present study is in close agreement with the prevalence found in Ossenberg's (2) Canadian caucasian mandibles, Italian mandibles, Eskimo (Inuit) mandibles and Japanese Ainu mandibles. Ossenberg significantly found a 0% prevalence of the RMF in black African mandibles included in her study. The absence of the RMF in her black African sample may be due to the relatively small sample size (n = 19), but the differences in her findings and those of the present study may reflect the influence of spatial, temporal and cultural differences between different black populations on the African continent. She reported significant differences between different native American populations, which may not be unusual due to their wide spatial distribution and cultural differences. She also reported differences in Japanese populations: the Ainu having a significantly higher RMF prevalence than other Japanese populations.

Ossenberg's (2) methods closely resemble those in the present study, with one important difference: the use of 0.5 mm as the smallest acceptable diameter of the RMF. It is probably appropriate to compare findings in the present study with those populations who showed a higher RMF prevalence in Ossenberg's study as a significant proportion of those mandibles would have been left out if the criteria applied in the present study were applied to the mandibles in Ossenberg's study. A fair comparison could therefore probably be made between the South African population and two native American groups: the Aluet (15.1%) and Northern Indians (15.2%). Bilecenoglu and Tuncer (6) also used a minimum RMF diameter of 0.5 mm as an inclusion criterion. They reported a 25% RMF prevalence in a Turkish sample. The presence of the RMF in South Africans and Turks may have been similar had the inclusion criteria been the same.

The departure from the 0.5 mm minimum diameter as an inclusion criterion for an identified RMF in favour of a larger 1.0 mm diameter represents an attempt to keep results as clinically relevant as possible. A smaller RMF would likely transmit a

smaller neurovascular bundle, effectively reducing the possibility and severity of clinical complications associated with the presence of the RMF.

Other studies placed no lower diameter as an inclusion criterion and as a result may not be comparable. (13, 15, 16, 18, 20-26) It was expected that studies using CBCT in living patients as a means of detecting the RMF would have a higher RMF prevalence as the inclusion criterion would be the presence of a visually perceptible RMC alone. This is indeed the case in studies by von Arx *et al*. (21), Kawai *et al*. (22), Lizio *et al*. (24), and Orhan *et al*. (26) The use of different modalities may explain the large difference between the findings of Ossenberg (2) and Kawai *et al*. (22) in Japanese populations (Ossenberg reported RMF prevalence values between 3.2% - 10.0% for Japanese subjects depending on the population under study, where Kawai *et al*. reported a 52% RMF prevalence in Japanese participants). This may be further influenced by temporal, spatial and cultural shifts between study populations, but the large increase in RMF prevalence seems mostly due to the change in the method of RMF detection.

The finding of von Arx *et al*. (21) that use of a PAN is a poor method to determine the presence of the RMC is significant. The use of a PAN to assess mandibular structures is more popular than CBCT due to its lower cost, greater availability, lower radiation dosage and greater familiarity among dentists. Clinicians who use PANs to assess the posterior mandible should keep the possible presence of an undetected RMF in mind at all times. The inability of Nortje *et al*. (11) to detect even one single RMC in their large survey of 3612 PANs provides enough evidence to adequately demonstrate this point (even in the presence of technological improvements in radiographic imaging over time).

Orhan *et al*. (26) reported a small female preference for the presence of the RMF, but it appears that sex does not play an important role in the development of the RMF and RMC. No factors which would influence this even distribution between the

sexes have been described. The finding in the present study that sex does not play a major role in the presence of the RMF is in agreement with results of studies by Ossenberg (2), Kodera and Hashimoto (16), Pyle *et al*. (17), Suazo *et al*. (20), and Von Arx *et al*. (21)

In the present study, a preference for a left-sided RMF was seen in the white female population. Six of the seven detected RMF were on the left and one of the seven appeared on the right. This is probably a reflection of the very small number of mandibles with a positive RMF rather than a clear preference for any one side. Other populations did not show a significant difference between the presence of the RMF on the right and left sides. This is in agreement with the general finding in other studies that there is no real preference for an RMF placed on any one side. (6, 20, 21, 25) Ossenberg (2) found a greater tendency for right-sided distribution in Old World populations; a result she found puzzling. Narayana *et al*. (18) showed a slight tendency for right sidedness of the RMF in unilateral presentations. Orhan *et al*. (26) reported a tendency for right sided RMFs. In light of the mostly even distribution of the RMF, placement of the RMF on the left or right side is probably not a finding of any developmental, surgical or anatomical importance.

The finding that there is no significant effect of age on the prevalence of the RMF casts doubt on Ossenberg's (2) theory that the RMF is a result of an increased neurovascular requirement due to the adolescent growth spurt. Ossenberg found that adolescents were the population with the greatest RMF prevalence, a finding not replicated in this study. Even though the sample is skewed towards an older population (i.e. contains very few mandibles of younger individuals), no statistically significant decrease in the prevalence of the RMF is seen with increasing age.

Persistence of the embryological structures observed by Chávez-Lomelí *et al.* (1) which may result in the picture of incomplete fusion of the branches of the inferior alveolar nerve and their accompanying bony canals seems to be an attractive

explanation for the presence of the RMF. It does, however, do little to explain the reasons behind the presentation of the retromolar neurovascular bundle as an aberrant buccal nerve. This unusual pattern of innervation may be the result of an aberrantly positioned buccal nerve during the development of the bony mandible or it may represent an anastomosis of the inferior alveolar nerve with a normally positioned buccal nerve. No evidence contradictory to, or in favour of, these possibilities has been produced. Further clinical and dissection studies are required to determine if the retromolar neurovascular bundle represents an anastomosis with a normal buccal nerve or, alternatively, if it supplies the area normally innervated by the buccal nerve without any interaction with such a structure.

6.1.2 The distance from the last mandibular molar to the RMF

The shortest distance from the last molar to the RMF may be used to estimate a safe distance for planning of incisions into the retromolar area. Any incision into the retromolar area beyond those measured in the study may result in an incision passing over or close to the RMF. Bleeding may be more difficult to control if the incision is made close to the RMF as the neurovascular bundle will possibly be harder to identify the closer it is to the opening of the RMF.

Bilencenoglu and Tuncer (6) reported a significantly smaller distance between M2 or M3 and the RMF than those found in the present study. No studies are available which compare dental arch lengths between South African and Turkish populations. It is uncertain whether or not an impacted M3 (when compared to a non-impacted M3) has any influence over this value. Other possible factors which may influence this distribution are unknown.

Motta-Junior *et al*. (23) reported similar distances from M3 to the RMF when compared to those found in the present study. The distance from M2 was not available in this study. Von Arx *et al*. (21) showed similar distances from M2 to the

RMF as found in the present study. The distance from M3 to the RMF was not determined. This is probably due to the variable nature of the position or angulation of M3 due to the high likelihood of M3 impaction. M3 may be partially or completely imbedded in bone and tilted in various directions. Because of this, care should be taken in interpreting the results of the distance of M3 to the RMF.

Factors influencing this distance have not been described but may include dental arch length and variation in individual tooth size in relation to the size of the mandible (i.e. an individual with a large tooth size in comparison to the size of the mandible may have the RMF placed closer to the last tooth in the arch along with a higher likelihood of an impacted M3). Comparisons of these variables between individuals and populations correlated with the distance from the RMF to the last tooth in the arch may facilitate understanding of the factors responsible for determining RMF position.

6.2 Characterisation of the internal structure of the RMC using MicroCT

MicroCT represents a fairly new method of studying fine structures of the bony mandible. This modality provides extremely high resolution images of skeletal samples allowing for nondestructive determination of the internal characteristics of the bony mandible.

Similarities between the findings of Schejtman *et al*. (4) and Carter and Keen (8) who used destructive methods to determine the internal characteristics of the RMF and associated RMC show agreement between anatomic anomalies found in direct inspection of bone with newer modalities such as CBCT and MicroCT.

The basic patterns described by Ossenberg (2) were largely preserved in the present study. Differences in the distribution of these types were found. Ossenberg showed a larger prevalence of type A RMCs where the present study showed a preference for type B RMCs. It is important to note that Ossenberg made no further division between different subcategories of these canal types. She also reported the TCC as a type C canal. This usage was abandoned in the present study. The small number of TCCs (Ossenberg's type C) was in agreement with Ossenberg's finding that it is an extremely rare variation. The absence of direct visualisation did not seem to affect Ossenberg's results in any way as she managed to produce schemes which were reproducible in the present study. It is also important to note that later classification schemes may have broken down what Ossenberg regarded as type B RMCs into two separate categories depending on the extent of the horizontal portion of the RMC.

The use of plain radiographs by Narayana *et al*. (18) revealed that a small majority of RMCs conformed to a Type I configuration (analogous to Ossenberg's type A). Type II configuration accounted for the second-most frequently found category in the study

by Narayana *et al*. (analogous to Ossenberg's type B). This is, once again, contradictory to the findings of the present study. No categories similar to the TCC or type C canals as used in the present study were found in the article by Narayana *et al*. (this might just be a result of vague and unclear explanations of RMC types in their article).

Von Arx *et al*. (21) used CBCT to determine the internal structure of the RMC, once again noting that type A canals (subtype A1) made up the largest group. Type B (specifically type B1) made up the second largest group. They reported that type C was never identified. Kawai *et al*. (22), Lizio *et al*. (24) and Orhan *et al*. (26) made no attempt at classification based on what was seen on CBCT.

The use of CBCT has been described as both similar to MSCT by Naitoh *et al.* (27) and superior to MSCT by Fukami *et al.* (9) for determining the pattern of fine structures of the mandible. CT (encompassing CBCT, MSCT and MicroCT) is superior to any other method of nondestructive RMC analysis. It may even be viewed as superior to bony dissection of the mandible as it allows the investigator the opportunity to study the mandible in different orientations and in sections through various planes multiple times without destroying the skeletal material.

The analysis of PANs to determine the presence of the RMF is unreliable and should therefore not be used in a survey to accurately detect prevalence or internal configuration of the RMC. Modalities such as CBCT, bony dissection and direct visualization with or without introduction of wire into canals are better methods for determining RMC structure. These sentiments are confirmed by the results of von Arx *et al.* (21) through their comparison of PANs and CBCT scans of the same patients.

There seems to be no apparent benefit in the use of MicroCT to determine the characteristics of the RMC. CBCT has consistently been used to resolve fine

structures of the mandible including the RMC. (7, 9, 21, 22, 24, 26) This is especially relevant when studying RMCs associated with a larger than 1 mm diameter RMF. The reduction in time used on CBCT units allocated to clinical dentistry seems to be the only benefit when studying RMCs. The disadvantages of fairly large datasets requiring specialised computer hardware and software for both acquisition and analysis of the scans makes the use of MicroCT an unnecessary waste of time and resources. That being said, these conclusions can only be drawn at the completion of a study, and this realisation, in itself, is extremely useful. MicroCT has provided us with a hammer and we should be selective about what we regard as a nail.

Surgical intervention involving soft tissues, teeth and osseous tissues in and around the retromolar area may result in haemorrhage due to damage to structures exiting, as well as housed within, the RMC. These surgical interventions include M3 removal, grafting of soft tissue, grafting of osseous tissues and orthognathic surgery (surgery for the correction of facial proportions due to skeletal defects).

M3 removal may require extensive use of rotary instruments (i.e. surgical drill and various burs and attachments) in and around the M3 socket. As the M3 and RMC have been seen to communicate with each other in certain cases, damage to the retromolar neurovascular bundle may result in haemorrhage in and around the socket of M3. This may be confused with a more serious complication – that of accessing the inferior alveolar canal. Knowledge of this variation may assist in distinction between the two complications.

The external oblique ridge may be used as an intra-oral donor site for osseous tissue used in augmentation of the alveolar ridges (in preparation for the support of dental implants or dentures). Its proximity to the RMF and associated canal may result in accidental damage to the structures housed within the RMC.

Orthognathic surgical intervention to shorten or lengthen the anteroposterior dimension of the mandible may be planned in such a way that the osteotomy site is placed through the plane of the RMC. This may be unavoidable. Segmental osteotomies of the posterior mandible (where one or more teeth may be moved to a higher or lower occlusal plane) may also leave this neurovascular bundle in danger. Orthognathic surgical intervention is usually performed by experienced clinicians (maxillo-facial and oral surgeons and registrars in the field) and as such, damage to the contents of the RMC may not be viewed as a significant intra-operative complication (the potential for damage to the inferior alveolar neurovascular bundle is of greater concern).

Intra-osseous placement of dental implants should pose no risk to the retromolar neurovascular bundle (other than posteriorly placed releasing incisions made into the gingival tissues). Implants are designed to replace teeth deemed necessary for aesthetics and function. The result is that implants are usually not placed distal to (posterior to) the area of the M2. Exceptions may be made in patients with limited bone stock in which an implant-supported denture is envisaged.

With the exception of cases where pre-identified RMF were determined to be TCCs after examination of tomograms, the RMC always started as an intra-osseous branch of the inferior alveolar canal. As local anaesthetic solution is usually injected at the mandibular foramen when mandibular anaesthesia is sought, there is not enough evidence based on this observation alone to attribute local anaesthetic failure to the presence of the RMF.

If this phenomenon does contribute to local anaesthetic failure, it is probably due to factors related to the conduction pattern of the inferior alveolar nerve and depth of the origin of the nerve fibres of the retromolar neurovascular bundle in the main trunk of the inferior alveolar nerve. Local anaesthetic failure may be due to the incomplete absorption of local anaesthetic by all nerve fibres within the main trunk of the inferior

alveolar nerve. Another explanation for local anaesthetic failure is that the neurovascular bundle in the RMC represents an anastomosis of the buccal nerve with, rather than a branch of, the inferior alveolar neurovascular bundle. The theory that the RMF and RMC is a result of incomplete fusion of branches of the inferior alveolar nerve and persistence of bony canals casts doubt on this possibility. Further anatomical and pharmacological study is needed to determine if local anaesthetic failure is actually related to the presence of the RMF and if so, how this effect is produced.

If the effect of local anaesthesia is explained using a gross anatomical model only (a model in which injection of local anaesthetic at a given point on a sensory nerve results in no conduction of nerve impulses past that point), it may seem logical that this variation may have no negative effect on the efficacy of local anaesthesia and may even serve to augment the effect of this anaesthesia – block anaesthesia at the mandibular foramen may result in anaesthesia of the normal distribution of the buccal nerve (this is assuming that the nerve fibres exiting the RMF represent an aberrant buccal nerve). Further study is needed to determine whether the nerve exiting the RMF is the only nerve innervating the area normally supplied by the buccal nerve or if it serves as additional innervation. Figure 6.1 shows nerve fibres exiting the RMF coursing towards the area normally innervated by the buccal nerve.

Inconsistencies in classification schemes add weight to Wyatt's (3) insistence that classification of the RMF and RMC is not useful and may rather be cause for confusion. Very noticeable differences in findings in the available literature and the structure of RMCs found in the present study in terms of configuration of the RMC was seen. This might be due to real differences between populations or inter-observer error. Whatever the cause, the decision to classify an RMC as a member of one category rather than another may hinge on as little as 1 mm displacement of any part of the RMC in any direction. The only real difference in RMC structure is the TCC, which enjoys a fairly questionable classification as an example of the RMC (only Ossenberg describes it as such and it does not represent a branch of the

inferior alveolar canal). If the model of Chávez-Lomelí *et al*. (1) is to be followed, it would seem that very small changes in positioning of nerve branches during the ossification process of the developing mandible is responsible for these changes. Whether functional, temporal or spatial changes or factors relating to ethnicity or cultural background are responsible for different shapes in which the RMC presents is probably not determinable.

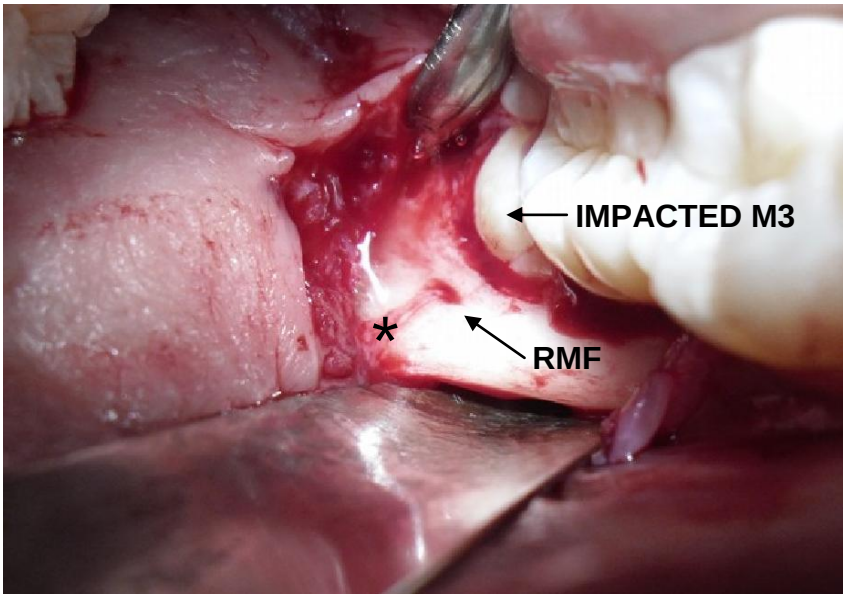

Figure 6.1 – Elements exiting the RMF course laterally towards the external oblique ridge (asterisk).

If a classification scheme is insisted upon, it should depart from the current descriptive system and be reformatted into a clinically relevant system describing its relationship to anatomical landmarks such as association with the last tooth in the arch, position in the ramus or angle of the mandible (or corpus – the distinction between corpus and angle of the mandible is often designated by the posterior border of M3, but may vary between practitioners), association with the inferior alveolar canal and the position of the RMF in the retromolar area. Due to the unreliability of a PAN to determine the course or existence of the RMC, classification would preferably be limited to CT scans only. The current classification schemes based on arbitrary canal shapes does little to further any useful clinical outcome.

6.3 Guideline for the management of the RMF in clinical dentistry

The complications usually associated with the RMF are local anaesthetic failure (3, 6-10, 18), interoperative haemorrhage (3, 6, 9) and paraesthesia of the normal distribution of the buccal nerve if damage to the associated neurovascular bundle occurs (3, 5, 9, 18). This guideline serves as a framework for dentists to approach treatment in patients presenting with the RMF. Potential complications and their management will be highlighted. Suggested changes in surgical approach will be offered. Discussion will be largely based on the assumption that the proposed procedure is surgical removal of an impacted M3.

6.3.1 Pre-operative assessment

Given that no single demographic variable recorded in this study (i.e. age, sex or race), produced any significant increase or decrease in the likelihood of a single patient presenting with a clinically significant RMF, it may be safe to approach all patients with the possibility of encountering the RMF on surgical exploration of the retromolar area. There does not seem to be any way of determining the likelihood of encountering the RMF on clinical examination alone (with the exception of age, race and sex, all of which has been determined insignificant in the studied sample, no studies have shown a link between the presence of any clinically evident signs or anomalies associated with increased prevalence of RMF).

Radiographic examination is required for adequate evaluation of patients who present with an impacted M3. Evaluation is usually undertaken to determine angulation of the M3, its position in the mandibular corpus or ramus, relationship with other teeth and its relationship with the inferior alveolar nerve. This evaluation can give a fairly accurate assessment of the ease of M3 removal or the risk if injury to adjacent structures. General evaluation of all radiographs should be undertaken to exclude the presence of any pathology or aberration.

Requested radiographs typically include a PAN, but these could also be oblique lateral views of the mandible or CT scans, whether CBCT or MSCT. Structures such as the RMC may be difficult to visualise using a PAN (21) or oblique lateral views of the mandible. CT scans may provide the clinician with a clear view of the RMF and RMC, (9, 21, 22, 24, 26, 27) but this modality may not be appropriate for the intention of identification of the RMF only (little benefit is derived from the use of such a modality when compared to the risks associated with exposure to unnecessary radiation and the increased cost of CT scans).

When a CT scan is requested it should preferably be a CBCT. CBCT may offer better resolution than MSCT (9, 27) (differences are expected between different machines and different settings, so the advantages in terms of resolution may not be significant) and lower scattering interference due to adjacent metal (e.g. in dental restorations). (27) Distinction between trabeculae in cancellous bone and fine canal structures is easier when using CBCT. (9) This modality is arguably the best method in terms of identification and visualisation of the RMC in a clinical setting.

6.3.2 Provision of local anaesthesia

The belief that local anaesthetic failure may be a result of the presence of the RMF (3, 6-10, 18) is questionable. MicroCT scans of dry mandibles clearly show branching of the RMC from the inferior alveolar canal. In cases of the TCC, no communication was seen between the TCC and the inferior alveolar canal. Ossenberg (10) did, however, describe communication between these two canals.

Failure of local anaesthesia can be divided into factors related to poor administration technique and patient factors such as anatomical variation, pathological change (e.g. presence of infection at the site of local anaesthetic injection) or psychological factors (anxious patients may report experiencing pain during procedures even if profound anaesthesia is obtained). (29) Since the RMC seems to represent a branch

of the inferior alveolar canal and no association with the presence of the RMF and changes in the position of the mandibular foramen seems to have been made, failure of local anaesthesia attributed to the presence of the RMF may, in reality, be an operator dependant failure.

If conventional inferior alveolar block anaesthesia does not appear to result in profound anaesthesia, alternative methods may be used. One such method is the Gow-Gates mandibular block in which local anaesthetic is deposited at the level of the condylar neck below the insertion of the lateral pterygoid muscle. The mouth is opened wide (as wide as possible while still staying within normal limits, i.e. without dislocation or subluxation of the condylar head). Landmarks used are the corner of the mouth and the lower border of the tragus extra-orally (creating a reference line along which the local anaesthetic needle should be projected), and the medial surface of the deep tendon of the temporalis muscle (for simplicity, medial surface of the external oblique ridge of the mandibular ramus). The needle is projected from a medial position intra-orally laterally towards the condylar neck. In this way anaesthesia of the posterior division of the mandibular nerve is achieved. (30-34) Available literature on the Gow-Gates mandibular block should be consulted for a full description and review of the technique. Figures 6.2 and 6.3 give an overview of the Gow-Gates mandibular block technique.

Infiltration into the area of the RMF may result in augmentation of local anaesthesia, but as this neurovascular bundle is considered a branch of the inferior alveolar nerve, pulpal anaesthesia should only take place if absorption of the local anaesthetic solution takes place at the site where the retromolar neurovascular bundle gives rise to branches to the roots of teeth, or inferior to that site. The likelihood of diffusion of local anaesthetic to the appropriate depth seems unlikely but further study into the action of different local anaesthetic agents will be required to determine the possible effectiveness of such an approach to anaesthesia.

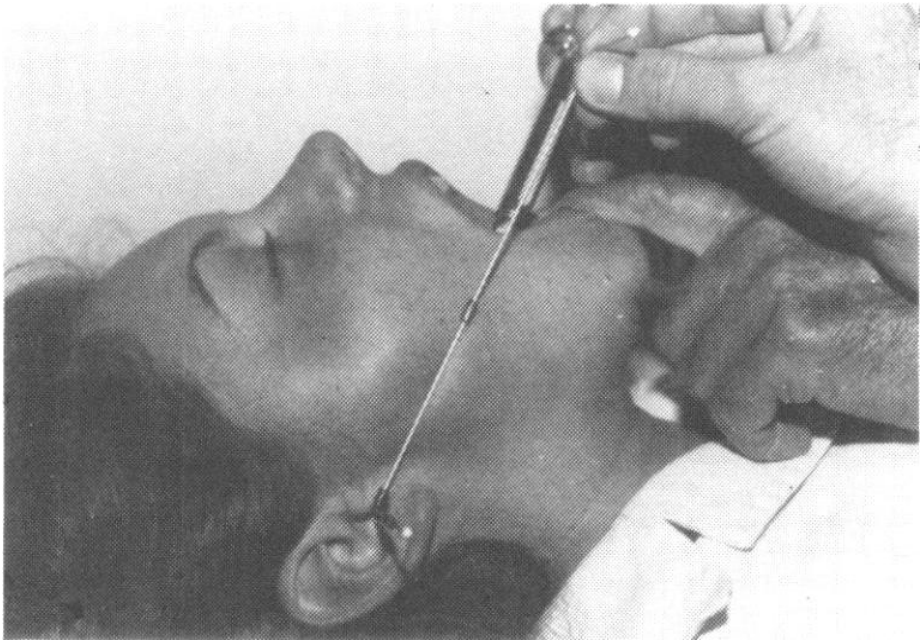

Figure 6.2 – Use of extra-oral landmarks for alignment of local anaesthetic in the Gow-Gates mandibular block. (31)

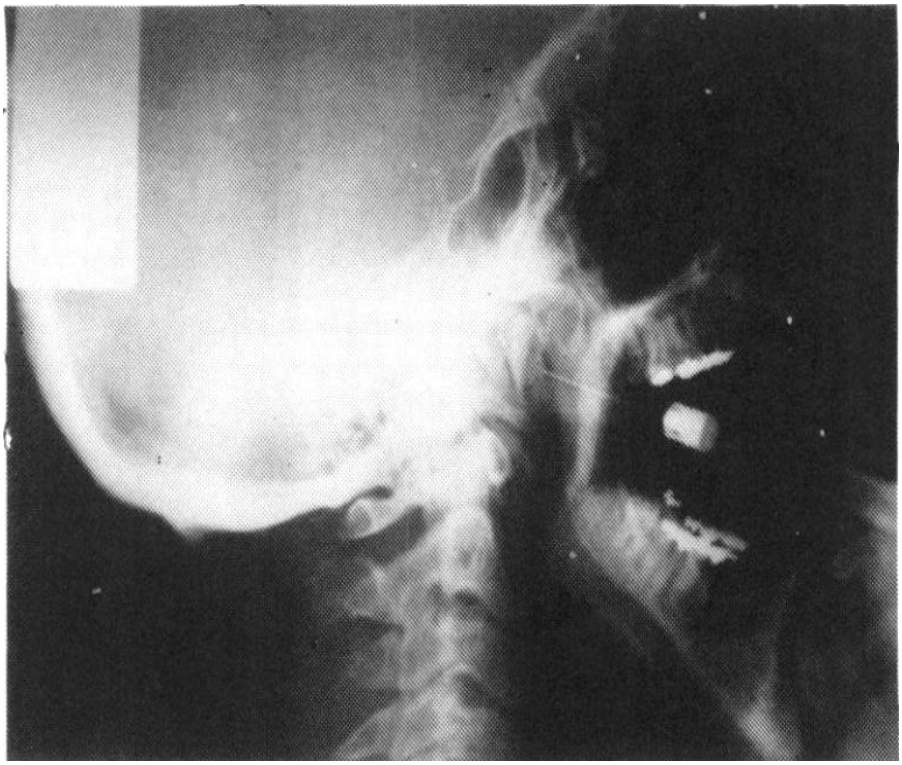

Figure 6.3 – Radiograph showing approximation of the needle to the condylar neck. (31)

Failure of anaesthesia might indicate that the contents of the RMC represent a branch of the buccal nerve (or other associated sensory nerve possibly arising from the cervical plexus) forming an anastomosis with the inferior alveolar nerve. If this is the case, local infiltration into the retromolar area should provide adequate anaesthesia (anaesthesia of the buccal nerve should indeed have already been administered in preparation for surgical intervention in the retromolar area or for simple extraction of mandibular molars).

Intraligamentary delivery of local anaesthetic solution may provide anaesthesia for a single tooth, but the orientation and level of submergence of an impacted M3 may render this method ineffective. Removal of an impacted M3 may require elevation of soft tissue flaps some distance from the tooth and removal of adjacent cancellous and cortical bone. The provision of intraligamentary injection may result in inadequate anaesthesia at sites adjacent to the tooth requiring removal.

As stated above, when studied on a gross anatomical scale, local anaesthetic failure does not seem to be a direct consequence of the presence of the RMF. Despite this, the association between the RMF and local anaesthetic failure seems to be well supported in published literature. (3, 6-10, 18)

6.3.3. Orientation of the retromolar neurovascular bundle in oral soft tissues

Singh (5) described a slender nerve moving laterally from the RMF, disappearing under the elevated flap in an antero-inferior direction. Bilencenoglu and Tuncer (6) did not describe the course of the nerve, but included a clinical photo of an example of the RMF and the associated neurovascular bundle. In this photo, the neurovascular bundle was seen to take a posterolateral direction. Tissue retraction may have resulted in more posterior placement of the bundle than normal (see figure 6.4). Von Arx *et al*. (7) also included a photo of an intra-operatively identified retromolar neurovascular bundle. The bundle in the photo also coursed

posterolaterally, possibly positioned more posteriorly due to tissue retraction (see figure 6.5). Figure 6.1 shows a similar pattern. All of the above are in agreement with the lateral element in the course of the retromolar neurovascular bundle. This position places the structure at risk during lateral incisions made for surgical access around an impacted M3.

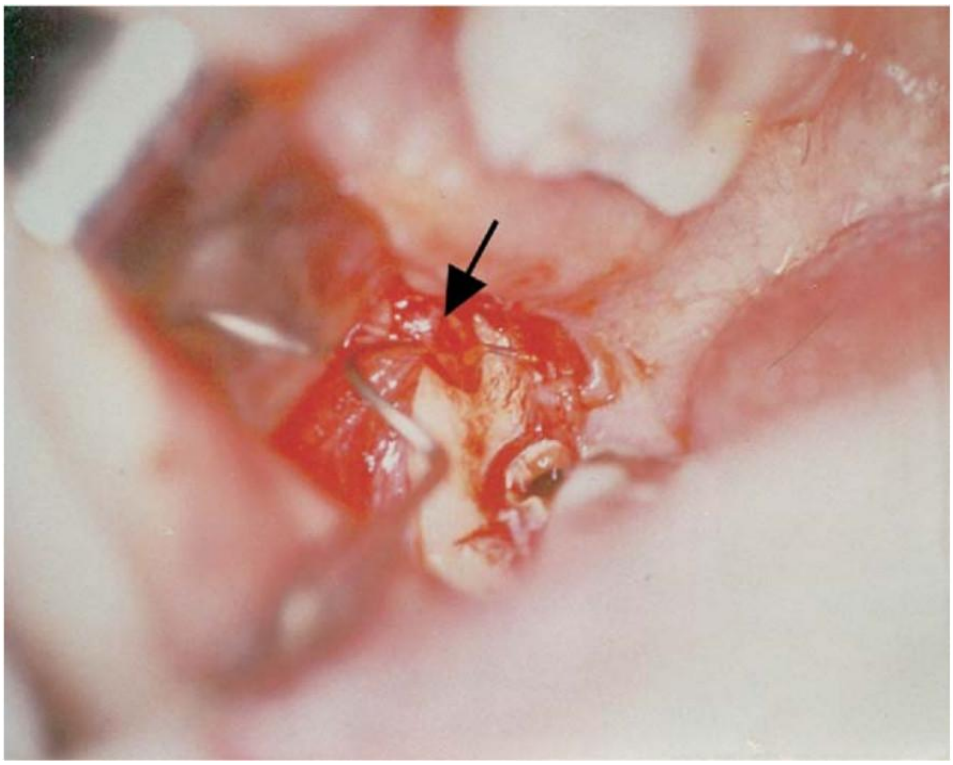

Figure 6.4 – Posterolateral course of the retromolar neurovascular bundle (black arrow). Note the influence of the retractor on the position of the neurovascular bundle. Compare figures 6.1 and 6.5. (6)

6.3.4 Surgical access

Surgical access during M3 removal would ideally be made to avoid the RMF and accompanying neurovascular elements. This might not be possible due to factors relating to tooth position. The approach to flap design is usually determined by the

surgeon's preference (and little value may be seen in changing preferred approaches to avoid a possible RMF or the structures escaping from it).

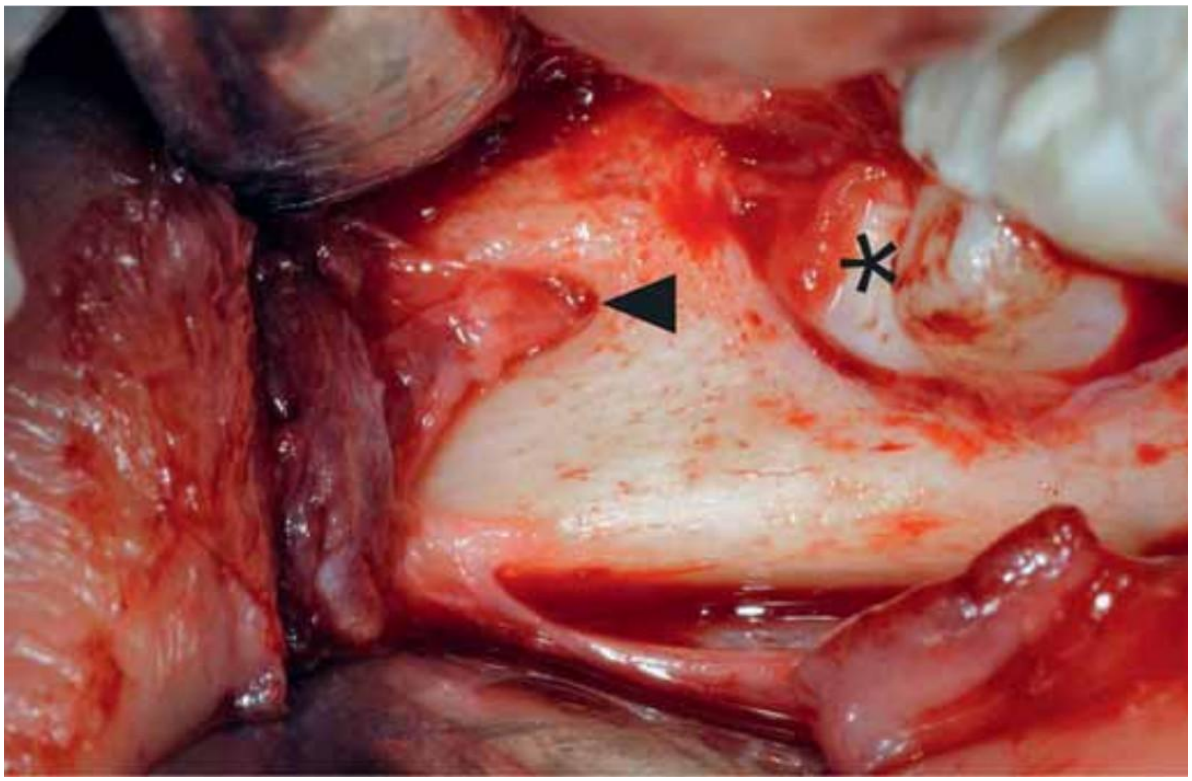

Figure 6.5 – Posterolateral course of the retromolar neurovascular bundle (black arrow) similar to the pattern seen in figures 6.1 and 6.4. Note the influence of the retractor on the position of the neurovascular bundle (asterisk – impacted M3). (7)

Fragiskos (35) describes two main flap designs, the triangular flap and the envelope flap. The envelope flap continues from the gingival sulci of the lower molar teeth posteriorly on to the external obique ridge (figure 6.1 shows an example of an envelope flap). The triangular flap makes use of an incision along the external oblique ridge and inferiorly into the vestibule, distal to the second molar (forming a flap which is trianglar in appearance). Modifications of the triangular flap usually entail incision into the gingival sulci before the vestibular incision is made.

It is important that these incisions be made on the external oblique ridge rather than straying medially. This will allow for easier identification of the retromolar neurovascular bundle in cases of haemorrhage. Its distance from the RMF may allow for easy ligation of the bundle to arrest bleeding. If the incision is made over the retromolar foramen the opportunity for haemostasis by ligation of soft tissues may not be afforded to the surgeon.

Alternative flap designs, such as described by Roode and Bütow (36), may be used instead of the more traditional flap designs described above. This flap makes use of a single incision running obliquely into the vestibule anterior to M3 (extends inferiorly towards the anterior limit). This may not be possible in all cases, but has been shown to result in lower post-operative morbidity (i.e. pain and swelling). This flap design is shown in figures 6.6 and 6.7. A lingual approach may be employed (i.e. elevation of soft tissue and removal of bone on the lingual side of the impacted M3) which will avoid the RMF. This approach is associated with increased risk of lingual nerve damage (a much larger complication than encountering the RMF) (37) and is not recommended as a means of avoiding the RMF.

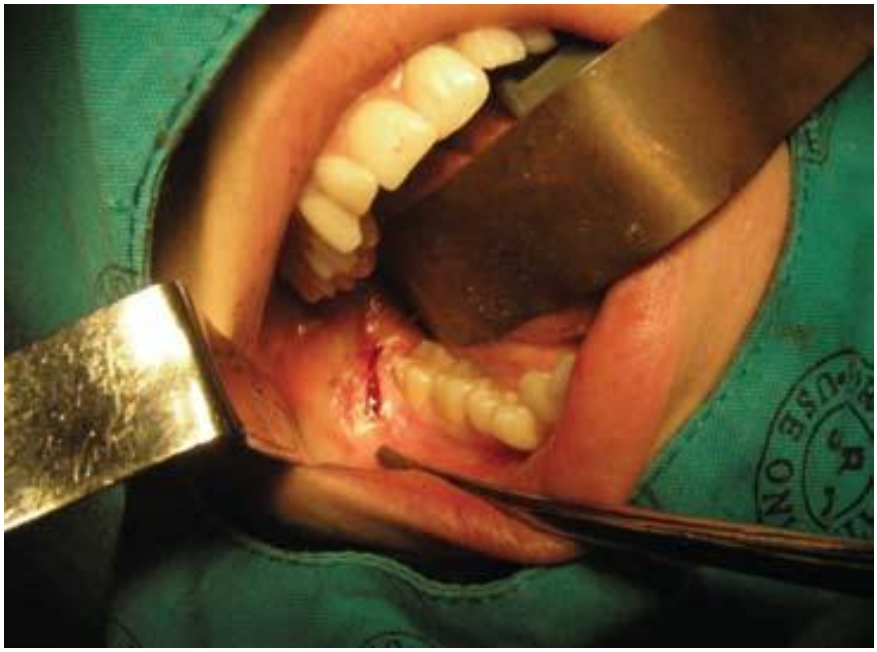

Figure 6.6 – Alternative flap design as described by Roode and Bütow. (36)

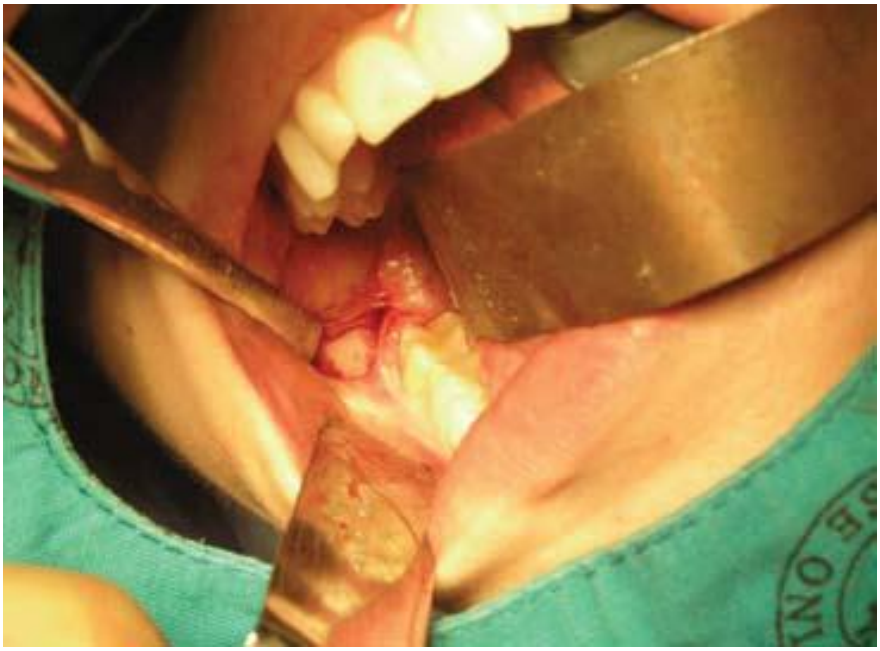

Figure 6.7 – Flap reflection as described by Roode and Bütow. (36)

6.3.5 Management of intra-operative haemorrhage

Intra-operative haemorrhage is probably the most likely complication associated the presence of the RMF. Bleeding from damaged blood vessels will not lead to significant blood loss in the average healthy patient but will serve to obscure the operative field and may be a cause of hesitation and frustrate the clinician (especially in the case of an inexperienced clinician).

Bleeding may be stopped by application of pressure (digital pressure if needed, but more commonly by burnishing of bone around the bleeding area or placement of sutures in soft tissue if bleeding originates from incised oral mucosa), application of haemostatic agents or use of other treatment modalities such as electrocoagulation.

Haemorrhage should, in most cases, be transient as vasoconstriction and clot formation is a normal physiological response to tissue injury. A simple method to reduce bleeding may be the introduction of local anaesthetic with adrenaline. The

vasoconstrictive effect of adrenaline should result in almost immediate reduction in bleeding if the source can be accurately identified. Patients with underlying medical conditions which serve to prolong bleeding time should be treated with their specific disorder in mind. A thorough medical history should be taken before any oral surgical intervention to prevent complications and to identify patients on anticoagulant drugs (including use of analgesics such as aspirin) and conditions which increase bleeding tendency.

6.3.6 Buccal nerve transection

This may not be a significant occurrence as sensory disturbance over small areas may go unnoticed. (38, 39) Available evidence seems to suggest that consequences of buccal nerve damage are minor and should be treated according to symptoms displayed by the patient.

It must be noted that the only complication associated with the presence of the RMF found in case reports was damage to the buccal nerve. (5) No other complications were reported in case studies found. This should not be taken as evidence that it is the most common complication, though, as bleeding is a fairly frequent encounter in oral surgery and may not represent an anomaly interesting enough to warrant publication.

6.3.7 Closure of surgical site and post-operative care

After the surgeon has inspected the surgical site and is satisfied that M3 removal is complete, closure of the site may be performed. There are no expected post-operative complications due to presence of the RMF. Patients may be given the same post-operative instructions and care as would be applied in cases without presence of the RMF.

6. CONCLUSION

A significant proportion of the South African population has at least one RMF. As no clinical signs correlated with an increased probability of possessing the structure have been identified, it may be safer to access the retromolar area of all South African patients assuming the presence of the RMF.

The RMF does not seem to represent a structure of great clinical importance. The link between the structure and local anaesthetic failure seems to be fairly well supported, but an anatomical study shows that this link is tenuous at best. Studies focussed on the conduction patterns of the inferior alveolar nerve and dissection studies to determine whether the contents of the RMC represent a branch of the inferior alveolar nerve or a buccal nerve anastomosing with the inferior alveolar nerve should be undertaken. Haemorrhage may occur but the absence of reported case studies focussing on this complication may indicate that haemorrhage is not considered a significant complication or may be easily controlled. The possibility of perineural spread of infective and invasive pathology may exist, although no reported cases have been found. The strongest evidence available for complications associated with the RMC is the possibility of loss of sensation in the distribution of the buccal nerve. This may represent the most important complication, but evidence suggests that loss of sensation due to buccal nerve transection is of little importance and may go largely undetected by patients.

The current classification schemes of the RMC seem to be of no clinical use. If a clinically acceptable scheme is to be devised it should focus on the relationship between the RMC and other anatomical structures rather than just offer a description of shapes in which RMCs may appear. Application of such a system should be confined to CT only, as other modalities of RMF detection in patients are unreliable.

The use of MicroCT, while an invaluable resource for non-destructive study, does not seem to be warranted in the study of bony canals of the diameter included in the present study. CBCT is sufficient for the study of RMCs in living patients and may be as easily applied to a study of dry mandibles.

Although clinical complications may not seem significant, the presence of the RMF may represent a source of anxiety for the inexperienced practitioner. Its status as a largely unknown anatomical variation may result in uncertainty during surgery. Adoption of the clinical framework outlined in the discussion should equip the clinician with all necessary knowledge required to take on cases in which the RMF appears with confidence.

The RMF should be approached with care to avoid potential complications during M3 surgery. It should, however, not be seen as a hindrance to adequate and necessary surgical intervention. No matter how insignificant, the reduced probability of surgical complications is in alignment with the principle of non-maleficence: “First, do no harm.”

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Appendix A: Data collection sheet for the RMF

Cadaver #	Left			Right		
	Presence of RMF	Distance from M2	Distance from M3	Presence of RMF	Distance from M2	Distance from M3

Appendix B: Random number generation programme (code)

```
# Programme name : randomRMF.py
# Programmer     : M. Yasin Gamieldien
# Language       : Python
# Version        : 3.3.0
# OS             : Linux (Ubuntu 12.10 'Quantal Quetzal')
# Purpose        : Written for the purpose of random number generation used in
#                  the selection of 50 random RMF from all identified RMF with a
#                  diameter greater than 1 mm in the Pretoria Bones Collection
#                  housed in the Department of Anatomy, University of Pretoria.
#                  Written as an adjunct to the completion of the requirements of
#                  MSc Anatomy of MY Gamieldien
#
# Comments       : As the MSc evaluation is carried out by those who most likely
#                  have limited knowledge of programming or computer science the
#                  code is heavily commented. Text after the '#' (hash) character
#                  are comments.
#                  An explanation of the processes will be provided.
#                  This programme generates pseudo-random numbers based on system
#                  time (that is time on the computer clock).
#
# Notice         : Although written for a selected purpose, this code may be
#                  used or modified for other purposes without the express
#                  consent of the programmer (MY Gamieldien)
#


#imports the python random library to allow random number generation

from random import *


#Opens RMFs.txt which contains a list of all hemimandibles in the prevalence
#study containing at least one RMF and reads them into a list and then
#calculates the number hemimandible number in the list (82) for future use

textfileRMF = open ('RMFs.txt')
elementsRMF = textfileRMF.readlines()
textfileRMF.close()

RMFnum = len(elementsRMF)


#Creates a loop executed 82 times (number of included RMF) to remove whitespace
#(i.e. elements which are not visible) that may be included in the RMF list

for j in range(0, RMFnum):
     elementsRMF[j] = elementsRMF[j].strip()


#creates a list 1 000 000 elements long to house RMF numbers in random places
#and assigns the number 9999999 to each of them to identify the elements as
#unused

randomRMFList = [9999999]*1000000



#Creates a loop executed 82 times to assign a random number to the variable i
#and places RMF numbers in the list at position i
```

```
#Loop repeats 82 times (number of included RMF)

for j in range(0, RMFnum):
      i = randrange(0, 1000000, 1)
    while (randomRMFList[i]!=9999999):
        i = randrange(0, 1000000, 1)
    randomRMFList[i] = elementsRMF[j]


#Initiates writing to randomRMF.txt which will contain a list of 50 random RMF

textfileRandomRMF = open ('randomRMF.txt', 'w')


#Creates a list of 50 elements long to house the 50 random RMF numbers and
#assigns the number 9999999 to each of them to identify the elements as unused

randomNumbers = [9999999]*50


#Creates a loop executed 50 times to select a random, non-repeating number -
#when a number is found which corresponds to the random position of a RMF, the
#RMF number is saved to a textfile

for j in range (0, 50):
    i = randrange(0, 1000000, 1)

    while ((randomRMFList[i] == 9999999) or (i in randomNumbers)):
        i = randrange(0, 1000000, 1)

    randomNumbers[j] = i
    strOut = (str(j+1) + '. ' + str(randomRMFList[i]) + "\n")
    textfileRandomRMF.write(strOut)
textfileRandomRMF.close()
```

Appendix C – Scanned RMF

Below is the output of the random number generation programme (Appendix B). The list contains all scanned RMF.

1. 6365R
2. 5020R
3. 5057R
4. 6423R
5. 5614R
6. 6325R
7. 5057L
8. 5792L
9. 5863R
10. 5250R
11. 5944L
12. 6232L
13. 5476L
14. 3094R
15. 5863L
16. 6259L
17. 6519L
18. 5177L
19. 5454L
20. 5693L
21. 6410L
22. 5086R
23. 6243L
24. 5809R
25. 5873R
26. 5806L
27. 5884L
28. 5872R
29. 6325L
30. 5884R
31. 5358L
32. 5315R
33. 5772L
34. 5657L
35. 5007R
36. 5573R
37. 5385L
38. 5463L
39. 5661R
40. 5012R
41. 5358R
42. 1636L
43. 5407L
44. 5296L
45. 5285L
46. 6305L
47. 5503L
48. 5256R
49. 4968L
50. 5282L

Appendix D: All included data

						Left			Right		
Cadaver no.	Sex	Race	Age	Mandible	RMF	RMF	DIST7	DIST8	RMF	DIST7	DIST8
1234	M	Black	50	1	N	0			0		
1763	M	Black	63	1	N	0			0		
1799	M	Black	84	1	N	0			0		
2352	M	Black	50	1	N	0			0		
4869	F	Black	21	1	N	0			0		
6338	F	White	21	1	N	0			0		
6192	F	Black	22	1	N	0			0		
2661	M	Black	70	1	N	0			0		
6512	F	White	22	1	N	0			0		
2741	M	Black	68	1	N	0			0		
2832	M	Black	66	1	N	0			0		
2899	M	Black	87	1	N	0			0		
2906	M	Black	50	1	N	0			0		
6290	F	Black	24	1	N	0			0		
3094	M	Black	52	1	Y	0			1		
3177	M	Black	56	1	Y	0			1		7.82
3178	M	Black	70	1	N	0			0		
3318	M	Black	53	1	N	0			0		
6234	F	Black	25	1	N	0			0		
3345	M	Black	57	1	N	0			0		
5892	F	Black	26	1	N	0			0		
3382	M	Black	66	1	N	0			0		
3442	M	Black	70	1	N	0			0		
3544	M	Black	48	1	N	0			0		
3657	M	Black	62	1	N	0			0		
3686	M	Black	73	1	N	0			0		
3700	M	White	77	1	Y	0			1	17.7	
3788	M	Black	56	1	N	0			0		
3849	M	Black	39	1	N	0			0		
3929	M	White	68	1	N	0			0		
3941	M	Black	70	1	N	0			0		
3953	M	Black	48	1	N	0			0		
3993	M	Black	40	1	N	0			0		
4046	M	White	60	1	N	0			0		
4063	M	White	57	1	N	0			0		
5797	F	Black	28	1	N	0			0		
4077	M	Black	70	1	N	0			0		
5957	F	Black	29	1	N	0			0		
4135	M	Black	50	1	N	0			0		
4194	M	White	77	1	N	0			0		

4195	M	Black	41	1	N	0	0		
4909	F	Black	30	1	N	0	0		
4196	M	Black	45	1	N	0	0		
4200	M	Black	59	1	N	0	0		
4208	M	Black	69	1	N	0	0		
4212	M	Black	35	1	N	0	0		
4217	M	Black	50	1	N	0	0		
4220	M	White	36	1	N	0	0		
6157	F	Black	30	1	Y	0	1		10.03
4228	M	Black	65	1	N	0	0		
4233	M	Black	40	1	N	0	0		
4236	M	Black	30	1	Y	0	1		10.24
4245	M	Black	70	1	N	0	0		
5150	F	Black	31	1	N	0	0		
4253	M	White	57	1	Y	0	1	19.24	
4254	M	Black	75	1	N	0	0		
4261	M	Black	78	1	Y	0	1		
4264	M	Black	56	1	N	0	0		
4290	M	White	63	1	N	0	0		
2866	F	Black	33	1	N	0	0		
6094	F	Black	33	1	N	0	0		
4293	M	Black	52	1	N	0	0		
4294	M	Black	72	1	N	0	0		
4296	M	Black	64	1	N	0	0		
5086	F	Black	34	1	Y	0	1		
4303	M	Black	55	1	N	0	0		
4305	M	Black	60	1	Y	0	1		9.91
4325	M	White	56	1	N	0	0		
4336	M	Black	35	1	N	0	0		
4340	M	Black	42	1	N	0	0		
4996	F	Black	35	1	N	0	0		
5259	F	Black	35	1	N	0	0		
5286	F	Black	35	1	N	0	0		
4346	M	Black	40	1	N	0	0		
4377	M	White	58	1	N	0	0		
4378	M	Black	50	1	N	0	0		
4380	M	Black	45	1	N	0	0		
4382	M	Black	46	1	N	0	0		
4403	M	Black	59	1	N	0	0		
4404	M	Black	30	1	N	0	0		
4405	M	Black	69	1	N	0	0		
4407	M	Black	45	1	N	0	0		
6463	F	Black	35	1	N	0	0		
4409	M	Black	56	1	Y	0	1		5.7
4411	M	Black	60	1	N	0	0		
4414	M	Black	48	1	N	0	0		

4418	M	Black	68	1	N	0	0
4421	M	Black	42	1	N	0	0
4425	M	Black	49	1	N	0	0
4429	M	Black	51	1	N	0	0
4430	M	Black	66	1	N	0	0
4431	M	Black	66	1	N	0	0
4433	M	Black	50	1	N	0	0
4448	F	Black	38	1	N	0	0
4434	M	Black	48	1	N	0	0
5306	F	Black	38	1	N	0	0
4435	M	Black	40	1	N	0	0
4438	M	Black	60	1	N	0	0
6000	F	Black	38	1	N	0	0
4443	M	Black	55	1	N	0	0
4445	M	Black	70	1	N	0	0
4446	M	Black	65	1	N	0	0
6372	F	Black	38	1	N	0	0
4453	M	Black	77	1	N	0	0
4456	M	Black	45	1	N	0	0
4457	M	White	71	1	N	0	0
4458	M	White	65	1	N	0	0
4459	M	White	74	1	N	0	0
4462	M	Black	65	1	N	0	0
4463	M	Black	50	1	N	0	0
4466	M	Black	65	1	N	0	0
4472	M	Black	60	1	N	0	0
4481	M	White	78	1	N	0	0
4578	F	Black	40	1	N	0	0
4483	M	Black	65	1	N	0	0
4489	M	Black	60	1	N	0	0
4491	M	Black	60	1	N	0	0
4518	M	White	79	1	N	0	0
4523	M	White	75	1	N	0	0
4534	M	Black	26	1	N	0	0
4536	M	Black	70	1	N	0	0
4538	M	Black	62	1	N	0	0
4568	M	Black	62	1	N	0	0
4582	M	Black	69	1	N	0	0
4583	M	Black	69	1	N	0	0
4592	M	Black	28	1	N	0	0
4601	M	White	62	1	N	0	0
5932	F	Black	40	1	N	0	0
4602	M	Black	60	1	N	0	0
4604	M	Black	60	1	N	0	0
4609	M	Black	50	1	N	0	0
4614	M	Black	53	1	Y	0	1

4617	M	Black	53	1	N	0		0	
4625	M	Black	49	1	N	0		0	
4638	M	White	56	1	N	0		0	
4641	M	Black	72	1	N	0		0	
4644	M	Black	65	1	N	0		0	
4648	M	Black	60	1	N	0		0	
4651	M	Black	18	1	N	0		0	
4653	M	Black	60	1	N	0		0	
4654	M	Black	64	1	N	0		0	
4656	M	Black	50	1	N	0		0	
4670	M	Black	59	1	N	0		0	
4746	F	Black	41	1	N	0		0	
4675	M	Black	60	1	N	0		0	
5156	F	Black	41	1	N	0		0	
4695	M	Black	60	1	N	0		0	
4697	M	Black	60	1	N	0		0	
4699	M	Black	70	1	N	0		0	
4256	F	Black	42	1	N	0		0	
4702	M	Black	70	1	N	0		0	
4709	M	Black	65	1	N	0		0	
4711	M	Black	65	1	N	0		0	
4712	M	Black	45	1	N	0		0	
4715	M	Black	65	1	N	0		0	
5628	F	Black	42	1	N	0		0	
4962	F	Black	43	1	N	0		0	
4724	M	Black	74	1	N	0		0	
4728	M	Black	60	1	N	0		0	
4731	M	Black	60	1	N	0		0	
4741	M	Black	60	1	N	0		0	
4742	M	Black	70	1	N	0		0	
4744	M	Black	65	1	N	0		0	
4747	M	Black	58	1	N	0		0	
4751	M	Black	70	1	N	0		0	
4754	M	White	71	1	N	0		0	
4870	F	Black	44	1	N	0		0	
4759	M	Black	60	1	Y	1	15.5	1	12.98
5335	F	Black	44	1	N	0		0	
4761	M	Black	60	1	N	0		0	
4766	M	Black	58	1	N	0		0	
4768	M	Black	64	1	N	0		0	
4769	M	Black	39	1	N	0		0	
4770	M	Black	80	1	N	0		0	
4773	M	Black	60	1	N	0		0	
4774	M	Black	51	1	N	0		0	
4775	M	Black	48	1	N	0		0	
4776	M	Black	73	1	N	0		0	

4780	M	Black	31	1	N	0		0	
4781	M	Black	77	1	N	0		0	
4784	M	Black	60	1	N	0		0	
4785	M	Black	56	1	N	0		0	
5056	F	White	45	1	N	0		0	
5201	F	Black	45	1	N	0		0	
4787	M	Black	65	1	N	0		0	
4789	M	Black	50	1	N	0		0	
4790	M	Black	61	1	N	0		0	
6028	F	Black	45	1	N	0		0	
4792	M	Black	45	1	N	0		0	
4793	M	Black	75	1	N	0		0	
4794	M	Black	40	1	N	0		0	
4798	M	Black	70	1	N	0		0	
4800	M	Black	50	1	N	0		0	
4808	M	Black	40	1	N	0		0	
5292	F	Black	46	1	N	0		0	
4809	M	Black	35	1	N	0		0	
4815	M	Black	65	1	N	0		0	
4816	M	Black	60	1	N	0		0	
6145	F	Black	46	1	N	0		0	
4821	M	Black	45	1	N	0		0	
4830	M	Black	50	1	N	0		0	
4836	M	Black	50	1	N	0		0	
4837	M	White	61	1	N	0		0	
4839	M	Black	55	1	N	0		0	
4565	F	Black	47	1	N	0		0	
4853	M	Black	46	1	N	0		0	
4856	M	Black	67	1	Y	1	15.36	1	9.02
4866	M	White	67	1	N	0		0	
6328	F	Black	47	1	N	0		0	
1636	F	Black	48	1	Y	1	6.49	1	9.4
4878	M	Black	45	1	N	0		0	
4885	M	Black	24	1	N	0		0	
4886	M	Black	45	1	N	0		0	
4892	M	Black	75	1	N	0		0	
4896	M	Black	56	1	N	0		0	
4901	M	Black	30	1	N	0		0	
5119	F	White	48	1	N	0		0	
4902	M	Black	34	1	N	0		0	
4908	M	Black	68	1	N	0		0	
4918	M	Black	70	1	N	0		0	
4925	M	Black	64	1	N	0		0	
4927	M	Black	72	1	N	0		0	
4928	M	Black	48	1	N	0		0	
4939	M	Black	44	1	N	0		0	

4941	M	Black	65	1	N	0			0		
4946	M	Black	96	1	N	0			0		
4947	M	Black	66	1	N	0			0		
4955	M	Black	50	1	N	0			0		
4959	M	Black	56	1	N	0			0		
4961	M	Black	66	1	N	0			0		
4968	M	Black	34	1	Y	1		15.2	0		
5654	F	Black	49	1	N	0			0		
4970	M	Black	55	1	N	0			0		
4979	M	Black	55	1	N	0			0		
4982	M	Black	56	1	N	0			0		
4983	M	Black	55	1	N	0			0		
4985	M	White	69	1	N	0			0		
4992	M	Black	67	1	N	0			0		
4995	M	Black	53	1	N	0			0		
5000	M	Black	69	1	N	0			0		
5006	M	Black	60	1	N	0			0		
4240	F	Black	50	1	N	0			0		
5007	M	Black	72	1	Y	0			1		
5012	M	Black	65	1	Y	0			1	8.78	
5014	M	Black	55	1	N	0			0		
4521	F	Black	50	1	N	0			0		
5020	M	Black	70	1	Y	0			1		
5022	M	Black	41	1	N	0			0		
5024	M	Black	70	1	N	0			0		
5025	M	Black	40	1	N	0			0		
5026	M	Black	24	1	N	0			0		
5032	M	Black	55	1	N	0			0		
4944	F	Black	50	1	Y	1	16		0		
5045	M	Black	70	1	N	0			0		
5051	M	Black	52	1	N	0			0		
5052	M	Black	65	1	N	0			0		
5054	M	Black	43	1	N	0			0		
5057	M	Black	50	1	Y	1		11.17	1		11.78
5063	M	Black	58	1	N	0			0		
5064	M	Black	70	1	N	0			0		
5066	M	White	74	1	N	0			0		
5067	M	Black	76	1	N	0			0		
5070	M	Black	55	1	N	0			0		
5075	M	Black	70	1	N	0			0		
5081	M	Black	65	1	N	0			0		
5082	M	Black	43	1	N	0			0		
5091	M	Black	65	1	N	0			0		
5101	M	Black	43	1	N	0			0		
5110	M	Black	65	1	N	0			0		
5117	M	Black	53	1	N	0			0		

5635	F	Black	50	1	N	0	0	
5121	M	Black	57	1	N	0	0	
5124	M	Black	42	1	N	0	0	
5127	M	White	78	1	N	0	0	
5132	M	Black	70	1	N	0	0	
5141	M	Black	60	1	N	0	0	
5142	M	Black	68	1	N	0	0	
5145	M	Black	75	1	N	0	0	
5149	M	Black	86	1	N	0	0	
5154	M	Black	50	1	N	0	0	
5155	M	White	51	1	N	0	0	
5158	M	White	65	1	N	0	0	
5160	M	Black	62	1	N	0	0	
5166	M	Black	64	1	N	0	0	
5167	M	Black	64	1	N	0	0	
5170	M	Black	66	1	N	0	0	
5173	M	White	55	1	N	0	0	
5174	M	Black	76	1	N	0	0	
5175	M	Black	55	1	N	0	0	
5177	M	Black	57	1	Y	1	0	
5178	M	Black	80	1	N	0	0	
5180	M	Black	47	1	N	0	0	
5181	M	Black	66	1	N	0	0	
5187	M	Black	50	1	N	0	0	
5190	M	Black	65	1	N	0	0	
5629	F	Black	52	1	N	0	0	
5192	M	Black	43	1	N	0	0	
5200	M	White	72	1	N	0	0	
5202	M	Black	60	1	N	0	0	
5214	M	Black	60	1	N	0	0	
5216	M	Black	63	1	N	0	0	
5222	M	Black	47	1	N	0	0	
5225	M	White	62	1	N	0	0	
5236	M	Black	69	1	N	0	0	
4636	F	Black	53	1	N	0	0	
5238	M	Black	50	1	N	0	0	
5243	M	Black	62	1	N	0	0	
5244	M	Black	63	1	N	0	0	
5246	M	Black	46	1	N	0	0	
6172	F	Black	53	1	Y	0	1	
4467	F	White	54	1	N	0	0	
5248	M	Black	80	1	N	0	0	
5250	M	Black	62	1	Y	0	1	12.81
5256	M	Black	69	1	Y	1	1	
5260	M	Black	75	1	N	0	0	
5261	M	Black	70	1	N	0	0	

5262	M	Black	37	1	N	0			0	
5269	M	Black	60	1	N	0			0	
5272	M	Black	66	1	N	0			0	
5273	M	Black	65	1	N	0			0	
5274	M	Black	64	1	N	0			0	
5276	M	Black	68	1	N	0			0	
5280	M	Black	32	1	N	0			0	
5285	M	Black	38	1	Y	1	11.99		0	
5287	M	Black	65	1	N	0			0	
5293	M	Black	27	1	N	0			0	
5296	M	Black	64	1	Y	1	29.37		0	
5013	F	Black	55	1	N	0			0	
5297	M	Black	65	1	N	0			0	
5301	M	Black	65	1	N	0			0	
5302	M	Black	50	1	N	0			0	
5303	M	Black	66	1	N	0			0	
5304	M	White	90	1	N	0			0	
5270	F	White	55	1	N	0			0	
5305	M	Black	80	1	N	0			0	
5307	M	Black	39	1	Y	1		11.52	0	
5309	M	Black	68	1	N	0			0	
5602	F	Black	55	1	N	0			0	
5310	M	Black	65	1	N	0			0	
5311	M	Black	50	1	N	0			0	
6461	F	White	55	1	N	0			0	
5312	M	Black	70	1	N	0			0	
5315	M	Black	69	1	Y	0			1	
5317	M	Black	35	1	N	0			0	
5321	M	Black	60	1	N	0			0	
5325	M	White	77	1	N	0			0	
5328	M	White	62	1	N	0			0	
4752	F	Black	56	1	N	0			0	
5329	M	Black	42	1	N	0			0	
5333	M	Black	60	1	N	0			0	
5345	M	Black	56	1	N	0			0	
5346	M	Black	75	1	N	0			0	
5347	M	White	64	1	N	0			0	
5352	M	Black	65	1	N	0			0	
5488	F	White	56	1	N	0			0	
5576	F	White	56	1	Y	1			0	
5354	M	Black	40	1	N	0			0	
5357	M	Black	70	1	N	0			0	
5785	F	Black	56	1	N	0			0	
5358	M	Black	53	1	Y	1		8.14	1	6.35
5359	M	Black	39	1	N	0			0	
6237	F	Black	56	1	N	0			0	

5360	M	Black	42	1	N	0			0
5361	M	Black	30	1	N	0			0
5364	M	Black	43	1	N	0			0
5365	M	Black	50	1	N	0			0
5368	M	Black	65	1	N	0			0
5370	M	Black	19	1	N	0			0
5342	F	Black	57	1	N	0			0
5372	M	Black	63	1	N	0			0
5607	F	White	57	1	N	0			0
5378	M	Black	70	1	Y	1			1
5379	M	Black	70	1	N	0			0
5380	M	Black	60	1	N	0			0
5895	F	White	57	1	N	0			0
5383	M	Black	75	1	N	0			0
5385	M	Black	56	1	Y	1	12.48		0
5386	M	Black	85	1	N	0			0
5387	M	White	55	1	N	0			0
5388	M	White	55	1	N	0			0
5389	M	Black	50	1	N	0			0
5391	M	Black	48	1	N	0			0
5980	F	Black	58	1	Y	1			0
5392	M	Black	70	1	N	0			0
6257	F	White	58	1	N	0			0
5403	M	Black	12	1	N	0			0
5407	M	White	73	1	Y	1		13.45	0
5415	M	Black	38	1	N	0			0
5417	M	Black	50	1	N	0			0
5418	M	White	68	1	N	0			0
5018	F	Black	59	1	N	0			0
5422	M	Black	70	1	N	0			0
6449	F	White	59	1	N	0			0
5423	M	Black	60	1	N	0			0
5424	M	Black	46	1	N	0			0
5428	M	Black	40	1	N	0			0
4417	F	Black	60	1	N	0			0
5429	M	Black	40	1	N	0			0
4449	F	Black	60	1	N	0			0
5431	M	Black	25	1	N	0			0
5432	M	Black	49	1	N	0			0
5434	M	White	80	1	N	0			0
5445	M	White	73	1	N	0			0
5446	M	Black	50	1	N	0			0
5448	M	Black	62	1	N	0			0
5449	M	Black	48	1	N	0			0
5450	M	Black	25	1	N	0			0
5454	M	Black	54	1	Y	1		8.52	0

5457	M	White	75	1	N	0		0
4727	F	Black	60	1	N	0		0
5461	M	Black	60	1	N	0		0
5462	M	Black	87	1	N	0		0
5463	M	Black	70	1	Y	1	11.18	0
5466	M	Black	71	1	N	0		0
5467	M	Black	61	1	N	0		0
5469	M	Black	51	1	N	0		0
5470	M	Black	49	1	N	0		0
5476	M	White	74	1	Y	1		1
5479	M	Black	75	1	N	0		0
5480	M	Black	55	1	N	0		0
5482	M	White	51	1	N	0		0
5483	M	Black	80	1	N	0		0
5264	F	White	60	1	N	0		0
5484	M	Black	46	1	Y	1	11.74	0
5486	M	Black	76	1	N	0		0
5493	M	Black	40	1	N	0		0
5501	M	White	77	1	N	0		0
5508	M	Black	18	1	N	0		0
5510	M	Black	75	1	N	0		0
5512	M	Black	80	1	N	0		0
5518	M	White	74	1	N	0		0
5522	M	Black	38	1	N	0		0
5525	M	Black	60	1	N	0		0
5553	F	White	60	1	N	0		0
5526	M	Black	80	1	Y	1		0
5531	M	White	66	1	N	0		0
5532	M	Black	54	1	N	0		0
5535	M	Black	50	1	N	0		0
5537	M	Black	49	1	N	0		0
5542	M	Black	57	1	N	0		0
5548	M	Black	60	1	N	0		0
5549	M	Black	60	1	N	0		0
5550	M	Black	60	1	N	0		0
5554	M	Black	80	1	N	0		0
5559	M	White	40	1	N	0		0
5561	M	Black	62	1	N	0		0
5563	M	Black	76	1	N	0		0
5564	M	Black	61	1	N	0		0
5565	M	Black	50	1	N	0		0
5566	M	Black	60	1	N	0		0
6370	F	Black	60	1	N	0		0
5569	M	Black	23	1	N	0		0
6470	F	Black	60	1	N	0		0
5570	M	White	83	1	N	0		0

5571	M	White	79	1	N	0		0	
5572	M	Black	35	1	N	0		0	
5573	M	White	80	1	Y	0		1	
5574	M	White	79	1	N	0		0	
5578	M	Black	50	1	N	0		0	
5579	M	Black	66	1	N	0		0	
5644	F	White	61	1	N	0		0	
5581	M	White	83	1	N	0		0	
5582	M	Black	78	1	N	0		0	
5584	M	Black	66	1	N	0		0	
6244	F	White	61	1	N	0		0	
5586	M	Black	51	1	N	0		0	
5587	M	White	84	1	Y	0		1	5.15
5590	M	Black	50	1	N	0		0	
5591	M	Black	40	1	N	0		0	
5592	M	White	74	1	N	0		0	
5598	M	Black	50	1	N	0		0	
5599	M	Black	85	1	N	0		0	
5601	M	Black	76	1	N	0		0	
5603	M	Black	32	1	N	0		0	
5608	M	White	57	1	N	0		0	
5613	M	Black	60	1	N	0		0	
5614	M	Black	50	1	Y	1	5.17	1	11.74
5615	M	Black	60	1	N	0		0	
5533	F	White	62	1	N	0		0	
5617	M	Black	48	1	N	0		0	
5568	F	White	62	1	N	0		0	
5946	F	Black	62	1	N	0		0	
5622	M	Black	61	1	Y	1		0	
5624	M	Black	76	1	N	0		0	
5626	M	White	51	1	N	0		0	
5627	M	Black	37	1	N	0		0	
4683	F	Black	63	1	N	0		0	
4998	F	Black	63	1	N	0		0	
5632	M	Black	41	1	N	0		0	
5636	M	Black	51	1	N	0		0	
5638	M	Black	35	1	N	0		0	
5534	F	White	63	1	N	0		0	
5640	M	White	52	1	N	0		0	
5642	M	White	61	1	N	0		0	
6016	F	White	63	1	Y	1		0	
5645	M	Black	76	1	N	0		0	
5646	M	Black	48	1	N	0		0	
5647	M	Black	50	1	N	0		0	
5653	M	Black	52	1	N	0		0	
5657	M	Black	50	1	Y	1		0	

5659	M	Black	56	1	N	0		0	
5661	M	Black	56	1	Y	0		1	19.15
5663	M	Black	36	1	N	0		0	
5665	M	Black	60	1	N	0		0	
5667	M	White	48	1	N	0		0	
5437	F	White	64	1	N	0		0	
5499	F	White	64	1	N	0		0	
5669	M	White	77	1	N	0		0	
5670	M	Black	40	1	N	0		0	
5671	M	Black	63	1	N	0		0	
5673	M	White	57	1	N	0		0	
5679	M	Black	52	1	Y	1	12.71	0	
6319	F	White	64	1	N	0		0	
5681	M	Black	53	1	N	0		0	
5683	M	White	65	1	N	0		0	
5684	M	White	80	1	N	0		0	
5685	M	Black	69	1	N	0		0	
5686	M	Black	70	1	N	0		0	
5688	M	White	52	1	N	0		0	
5691	M	Black	43	1	N	0		0	
5697	M	Black	60	1	N	0		0	
5702	M	Black	60	1	N	0		0	
5704	M	Black	66	1	N	0		0	
5719	M	White	76	1	N	0		0	
5728	M	Black	70	1	N	0		0	
5735	M	Black	50	1	N	0		0	
4855	F	Black	65	1	N	0		0	
5737	M	Black	65	1	N	0		0	
5743	M	Black	70	1	N	0		0	
5746	M	Black	49	1	N	0		0	
5747	M	White	72	1	N	0		0	
5748	M	White	85	1	N	0		0	
5751	M	Black	43	1	N	0		0	
5752	M	Black	52	1	N	0		0	
5754	M	White	74	1	N	0		0	
5755	M	White	59	1	N	0		0	
5756	M	Black	61	1	N	0		0	
5757	M	Black	35	1	N	0		0	
5759	M	White	86	1	N	0		0	
5760	M	Black	66	1	N	0		0	
5761	M	Black	28	1	N	0		0	
5768	M	Black	75	1	N	0		0	
5373	F	White	65	1	N	0		0	
5772	M	Black	65	1	Y	1		0	
5789	M	White	79	1	N	0		0	
5792	M	White	77	1	Y	1		0	

5794	M	Black	65	1	N	0	0	
5796	M	Black	30	1	N	0	0	
5798	M	Black	50	1	N	0	0	
5799	M	White	80	1	N	0	0	
6156	F	Black	65	1	N	0	0	
5800	M	White	70	1	N	0	0	
5805	M	White	73	1	N	0	0	
6339	F	White	65	1	N	0	0	
5809	M	Black	60	1	Y	0	1	5.14
5810	M	Black	70	1	N	0	0	
5811	M	White	74	1	N	0	0	
5813	M	Black	70	1	N	0	0	
4464	F	Black	66	1	N	0	0	
5814	M	White	72	1	N	0	0	
5816	M	Black	29	1	N	0	0	
5819	M	Black	46	1	N	0	0	
5820	M	Black	64	1	N	0	0	
5821	M	White	81	1	N	0	0	
5828	M	Black	65	1	N	0	0	
5829	M	Black	65	1	N	0	0	
5830	M	Black	60	1	N	0	0	
5831	M	Black	45	1	N	0	0	
5832	M	White	54	1	N	0	0	
5837	M	Black	48	1	N	0	0	
5838	F	White	66	1	N	0	0	
5840	M	White	73	1	N	0	0	
6229	F	White	66	1	N	0	0	
5841	M	Black	64	1	N	0	0	
5842	M	White	76	1	N	0	0	
4905	F	Black	67	1	N	0	0	
5844	M	Black	63	1	N	0	0	
5098	F	White	67	1	N	0	0	
5593	F	White	67	1	N	0	0	
5845	M	Black	44	1	N	0	0	
5847	M	Black	54	1	N	0	0	
6365	F	White	67	1	Y	0	1	
6379	F	White	67	1	N	0	0	
5848	M	White	61	1	N	0	0	
5855	M	Black	24	1	N	0	0	
5856	M	Black	27	1	N	0	0	
5858	M	White	75	1	N	0	0	
5860	M	Black	54	1	N	0	0	
5108	F	Black	68	1	N	0	0	
5863	M	Black	45	1	Y	1	1	14.66
5865	M	White	76	1	N	0	0	
5866	M	White	54	1	N	0	0	

5867	M	White	71	1	N	0		0
5868	M	Black	25	1	N	0		0
5870	M	Black	30	1	N	0		0
5871	M	Black	40	1	N	0		0
5872	M	White	69	1	Y	0		1
5873	M	White	77	1	Y	0		1
5875	M	White	64	1	N	0		0
5876	M	Black	69	1	N	0		0
5880	M	Black	57	1	N	0		0
5882	M	Black	54	1	N	0		0
5884	M	White	69	1	Y	1		1
5885	M	Black	32	1	N	0		0
5886	M	Black	71	1	N	0		0
5612	F	White	69	1	N	0		0
5893	M	White	73	1	N	0		0
5899	M	Black	40	1	N	0		0
5902	M	Black	74	1	N	0		0
5903	M	Black	30	1	N	0		0
5905	M	Black	40	1	N	0		0
5909	M	White	64	1	N	0		0
5911	M	Black	74	1	N	0		0
6245	F	White	69	1	N	0		0
5912	M	Black	37	1	N	0		0
5914	M	Black	61	1	N	0		0
5916	M	White	77	1	N	0		0
5920	M	Black	60	1	Y	1	4.76	0
5922	M	White	72	1	N	0		0
5923	M	White	86	1	N	0		0
5924	M	White	69	1	N	0		0
5928	M	Black	55	1	N	0		0
5930	M	White	81	1	N	0		0
5931	M	Black	50	1	N	0		0
5935	M	White	71	1	N	0		0
5940	M	Black	57	1	N	0		0
5942	M	Black	41	1	N	0		0
5944	M	White	56	1	Y	1		0
5947	M	Black	48	1	N	0		0
5952	M	Black	70	1	N	0		0
5033	F	Black	70	1	N	0		0
5039	F	Black	70	1	N	0		0
5953	M	Black	27	1	N	0		0
5954	M	Black	36	1	N	0		0
5955	M	Black	50	1	N	0		0
5958	M	Black	34	1	N	0		0
5959	M	Black	69	1	N	0		0
5960	M	White	49	1	N	0		0

5962	M	Black	72	1	N	0	0	
5966	M	Black	77	1	N	0	0	
5967	M	Black	40	1	N	0	0	
5974	M	Black	66	1	N	0	0	
5975	M	Black	31	1	N	0	0	
5976	M	Black	70	1	N	0	0	
5981	M	Black	45	1	N	0	0	
5710	F	White	70	1	N	0	0	
5982	M	Black	80	1	N	0	0	
5985	M	Black	57	1	N	0	0	
5989	M	Black	30	1	N	0	0	
5990	M	Black	70	1	N	0	0	
5991	M	Black	71	1	N	0	0	
5999	M	White	47	1	N	0	0	
6002	M	Black	36	1	N	0	0	
6003	M	Black	35	1	Y	0	1	8.1
5998	F	White	70	1	N	0	0	
6005	M	Black	70	1	N	0	0	
6010	F	Black	70	1	N	0	0	
6007	M	White	80	1	N	0	0	
6008	M	White	48	1	N	0	0	
6011	M	Black	60	1	N	0	0	
6294	F	White	70	1	N	0	0	
6012	M	Black	35	1	N	0	0	
6013	M	White	76	1	N	0	0	
6018	M	Black	65	1	N	0	0	
6023	M	Black	50	1	N	0	0	
6025	M	Black	56	1	N	0	0	
6030	M	Black	26	1	N	0	0	
6031	M	White	58	1	N	0	0	
5708	F	Black	71	1	N	0	0	
6034	M	Black	35	1	N	0	0	
6044	M	Black	60	1	N	0	0	
5918	F	White	71	1	N	0	0	
6058	M	Black	30	1	N	0	0	
6081	M	Black	60	1	N	0	0	
6085	M	Black	60	1	N	0	0	
6087	M	Black	44	1	N	0	0	
6104	M	White	75	1	N	0	0	
6442	F	White	71	1	N	0	0	
6105	M	White	82	1	N	0	0	
6120	M	Black	39	1	N	0	0	
6129	M	Black	41	1	N	0	0	
6137	M	Black	40	1	N	0	0	
6141	M	Black	40	1	N	0	0	
5577	F	White	72	1	N	0	0	

5580	F	White	72	1	N	0		0	
6142	M	Black	43	1	N	0		0	
5750	F	White	72	1	N	0		0	
6173	M	Black	40	1	N	0		0	
6182	M	Black	40	1	N	0		0	
6183	M	Black	36	1	Y	1	21.01	0	
6186	M	Black	39	1	N	0		0	
6378	F	White	72	1	N	0		0	
6188	M	Black	25	1	N	0		0	
6195	M	Black	46	1	N	0		0	
6197	M	Black	67	1	N	0		0	
4376	F	Black	73	1	N	0		0	
6198	M	White	71	1	N	0		0	
6199	M	Black	27	1	N	0		0	
6205	M	White	84	1	N	0		0	
5595	F	White	73	1	N	0		0	
5674	F	White	73	1	N	0		0	
6210	M	Black	64	1	N	0		0	
6217	M	Black	35	1	N	0		0	
6218	M	Black	26	1	N	0		0	
6219	M	White	67	1	N	0		0	
6220	M	Black	27	1	N	0		0	
6223	M	White	69	1	Y	0		1	11.6
5118	F	White	74	1	N	0		0	
6225	M	Black	44	1	N	0		0	
6228	M	White	55	1	N	0		0	
6230	M	White	85	1	N	0		0	
5668	F	White	74	1	N	0		0	
5739	F	White	74	1	N	0		0	
6231	M	Black	32	1	N	0		0	
5769	F	White	74	1	N	0		0	
6232	M	White	85	1	Y	1		0	
6235	M	Black	45	1	N	0		0	
6236	M	Black	80	1	N	0		0	
6041	F	White	74	1	N	0		0	
6254	F	White	74	1	N	0		0	
6238	M	White	80	1	N	0		0	
6239	M	Black	34	1	N	0		0	
6468	F	White	74	1	N	0		0	
6481	F	White	74	1	N	0		0	
6241	M	White	87	1	N	0		0	
4399	F	Black	75	1	N	0		0	
6242	M	Black	65	1	N	0		0	
4556	F	White	75	1	N	0		0	
6247	M	Black	54	1	N	0		0	
6248	M	White	49	1	N	0		0	

6249	M	Black	77	1	N	0		0
5203	F	Black	75	1	N	0		0
6251	M	Black	27	1	N	0		0
6252	M	Black	46	1	N	0		0
6253	M	White	86	1	N	0		0
6258	M	Black	38	1	N	0		0
6261	M	Black	74	1	N	0		0
6280	M	Black	46	1	N	0		0
5605	F	White	75	1	N	0		0
5765	F	White	75	1	N	0		0
6281	M	Black	60	1	N	0		0
6283	M	White	77	1	N	0		0
6284	M	Black	61	1	N	0		0
6345	F	White	75	1	N	0		0
6286	M	Black	70	1	N	0		0
6288	M	White	70	1	N	0		0
6289	M	White	46	1	N	0		0
6291	M	Black	65	1	N	0		0
6292	M	Black	70	1	N	0		0
5472	F	White	76	1	N	0		0
6296	M	Black	58	1	N	0		0
6297	M	Black	30	1	N	0		0
5588	F	White	76	1	N	0		0
6299	M	Black	48	1	N	0		0
6300	M	Black	38	1	N	0		0
6301	M	Black	62	1	N	0		0
6302	M	White	79	1	N	0		0
5806	F	White	76	1	Y	1		0
6305	M	Black	50	1	Y	1	22.28	0
6306	M	White	76	1	N	0		0
6307	M	White	70	1	N	0		0
6308	M	Black	40	1	N	0		0
6451	F	White	76	1	N	0		0
6309	M	Black	70	1	N	0		0
6310	M	White	74	1	N	0		0
6312	M	Black	27	1	N	0		0
6313	M	White	91	1	N	0		0
6314	M	Black	26	1	N	0		0
6316	M	White	56	1	N	0		0
6317	M	Black	38	1	N	0		0
6318	M	Black	36	1	N	0		0
6323	M	Black	40	1	N	0		0
6325	M	White	77	1	Y	1	13.24	1
6327	M	White	72	1	N	0		0
5983	F	White	77	1	N	0		0
6117	F	White	77	1	N	0		0

6246	F	White	77	1	N	0	0
6329	M	Black	78	1	N	0	0
6330	M	White	80	1	N	0	0
6331	M	Black	62	1	N	0	0
6332	M	Black	44	1	N	0	0
6360	F	White	77	1	N	0	0
6362	F	White	77	1	N	0	0
6333	M	White	77	1	N	0	0
6334	M	Black	35	1	N	0	0
6479	F	White	77	1	N	0	0
6335	M	Black	54	1	N	0	0
6337	M	Black	68	1	N	0	0
6341	M	White	89	1	N	0	0
6343	M	White	54	1	N	0	0
6208	F	White	78	1	N	0	0
6344	M	Black	80	1	N	0	0
6348	M	White	61	1	N	0	0
6350	M	Black	46	1	N	0	0
6351	M	Black	60	1	N	0	0
5464	F	White	79	1	N	0	0
5506	F	White	79	1	N	0	0
6354	M	Black	40	1	N	0	0
6356	M	White	60	1	N	0	0
5583	F	White	79	1	N	0	0
5623	F	White	79	1	N	0	0
6359	M	Black	82	1	N	0	0
6366	M	Black	77	1	N	0	0
6367	M	White	78	1	N	0	0
6465	F	White	79	1	N	0	0
6371	M	Black	27	1	N	0	0
4384	F	Black	80	1	N	0	0
6374	M	White	51	1	N	0	0
6376	M	Black	37	1	N	0	0
6380	M	White	71	1	N	0	0
6381	M	White	75	1	N	0	0
6385	M	White	80	1	N	0	0
6386	M	White	72	1	N	0	0
5495	F	White	80	1	N	0	0
6389	M	Black	45	1	N	0	0
6392	M	White	77	1	N	0	0
6395	M	Black	40	1	N	0	0
6398	M	White	51	1	N	0	0
6400	M	Black	68	1	N	0	0
5774	F	White	80	1	N	0	0
6401	M	Black	58	1	N	0	0
6402	M	White	40	1	N	0	0

6403	M	Black	22	1	N	0			0	
6404	M	Black	45	1	N	0			0	
6409	M	Black	70	1	N	0			0	
6410	M	Black	43	1	Y	1		9.14	0	
6411	M	Black	60	1	N	0			0	
6412	M	Black	82	1	N	0			0	
5473	F	White	81	1	N	0			0	
6413	M	Black	61	1	N	0			0	
6416	M	Black	30	1	N	0			0	
5970	F	White	81	1	N	0			0	
6243	F	White	81	1	Y	1			0	
6259	F	White	81	1	Y	1	19		0	
6322	F	White	81	1	N	0			0	
6473	F	White	81	1	N	0			0	
5766	F	White	82	1	N	0			0	
6417	M	Black	27	1	N	0			0	
6423	M	Black	33	1	Y	0			1	16.42
6361	F	White	82	1	N	0			0	
6426	M	Black	98	1	N	0			0	
6421	F	White	82	1	N	0			0	
6445	F	White	82	1	N	0			0	
6427	M	White	75	1	N	0			0	
6480	F	White	82	1	N	0			0	
5163	F	White	83	1	N	0			0	
6429	M	Black	40	1	N	0			0	
6430	M	Black	50	1	N	0			0	
6233	F	White	83	1	N	0			0	
6433	M	White	71	1	N	0			0	
6435	M	White	85	1	N	0			0	
6437	M	White	78	1	N	0			0	
6438	M	Black	40	1	N	0			0	
6282	F	White	84	1	N	0			0	
6439	M	Black	30	1	N	0			0	
6440	M	Black	50	1	N	0			0	
6444	M	White	68	1	N	0			0	
6446	M	White	83	1	N	0			0	
6227	F	White	85	1	N	0			0	
6448	M	White	75	1	N	0			0	
6452	M	White	79	1	N	0			0	
6456	M	Black	49	1	N	0			0	
6458	M	Black	50	1	N	0			0	
5299	F	White	86	1	N	0			0	
5558	F	White	86	1	N	0			0	
5693	F	White	86	1	Y	1			0	
6459	M	Black	57	1	N	0			0	
6466	M	White	40	1	N	0			0	

6471	M	Black	82	1	N	0		0
6320	F	White	86	1	N	0		0
6472	M	White	70	1	N	0		0
6475	M	White	84	1	N	0		0
5489	F	White	87	1	N	0		0
5575	F	White	87	1	N	0		0
5801	F	White	87	1	N	0		0
6477	M	White	79	1	N	0		0
5898	F	White	88	1	N	0		0
6240	F	White	88	1	N	0		0
5744	F	White	89	1	N	0		0
6484	M	White	72	1	N	0		0
6519	M	Black	67	1	Y	1	8.78	0
6396	F	White	90	1	N	0		0
6538	M	Black	63	1	N	0		0
6539	M	Black	40	1	N	0		0
6542	M	Black	60	1	N	0		0