A RETROSPECTIVE ANALYSIS OF GUNSHOT INJURIES TO THE MAXILLOFACIAL REGION (1980 TO 1995)

by

ASHWIN HARKISON KASSAN

Dissertation submitted in partial fulfilment of the requirements for the degree of Magister Chirurgiae Dentium in the discipline of Maxillofacial and Oral Surgery in the Faculty of Dentistry, WHO Collaboration Centre, University of the Western Cape.

SUPERVISORS

PROF. G. KARIEM (Head: Department of Maxillofacial and Oral Surgery, University of the Western Cape)

DR. R. LALLOO (Consultant: Department of Community Dentistry, University of the Western Cape)

DATE OF SUBMISSION (October 1997)

DECLARATION

I, ... declare that this dissertation entitled "**A RETROSPECTIVE ANALYSIS OF GUNSHOT INJURIES TO THE MAXILLOFACIAL REGION (1980 TO 1995)**" is my own work and that all sources I have quoted have been indicated and acknowledged by means of references.

Signed: ....

ACKNOWLEDGEMENTS

I wish to acknowledge my sincere gratitude to the following individuals for their assistance in this research project.

(1) Miss F. Faroon for her kind assistance and proficiency with the word–processing and for her patience and forbearance.

(2) Professor G. Kariem and Dr. R. Lalloo, my supervisors, for their invaluable guidance and assistance in making this study possible.

(3) Dr. R. Lalloo, for his proficient assistance with the processing of the data and the statistics.

(4) Mrs H. Hale for her patience in the collection of the hospital records.

(5) Dr. N. Patel, for his invaluable assistance with the presentation of the graphic material.

(6) The Medical Graphics Department (Groote Schuur Hospital) for their assistance with the photography.

(7) My consultants, Prof. G. Kariem, Dr. G. Hein, Dr. A. Mohamed and fellow registrars, Dr. V. Rughubar, Dr. S. Singh for their constant advice.

(8) Dr. A. Fleming, for his kind advice and assistance.

(9) I am indebted to the many patients who made this study possible.

(10) A special expression of gratitude to all those individuals whom I may have omitted, and to those who have supported and inspired me throughout my training as a registrar in the field of Maxillofacial and Oral Surgery.

DEDICATION

This dissertation is dedicated to my mother, whose sacrifices and love has made my education possible, and to my brother and other members of my family for their support and encouragement. I would like to extend a special dedication to my late father, whose constant motivation has resulted in my tertiary education. His inspirations will always be remembered.

DEFINITION OF TERMS

Maxillofacial region:

The anatomical region of the face excluding the cranium and its contents and the neck. This region includes the orbit and its contents, the maxilla, zygomatic bones, the nose, maxillary and mandibular alveoli, the teeth, the ears, the mandible, the oral cavity and its contents and the oropharynx (Rowe *et al.*, 1985).

Comminuted:

Refers to fractures of bone into multiple fragments (Rowe *et al.*, 1985).

Graft:

Any organ or tissue used for implantation or transplantation (Rowe *et al.*, 1985).

Vascularized bone graft:

A bone graft with attached blood vessels (Rowe *et al.*, 1985).

Avulsive wounds:

Massive open wounds with loss of tissue (Rowe *et al.*, 1985).

ABSTRACT

There appears to be an increase in the use of handguns amongst the civilian population with a resultant increase in the firearm related mortalities in the Cape Town metropolitan area (Lerer *et al.*, 1997). Therefore, the aim of the study was to analyse the demographic data, patterns, management and complications of gunshot injuries to the maxillofacial region.

This is a retrospective study of gunshot injuries to the maxillofacial region treated at Groote Schuur Hospital, Cape Town over a 15 year period (1980–1995). A total number of 301 cases were analysed.

Maxillofacial gunshot injuries are increasing exponentially over the years with most of these occurring post 1990. The majority of these injuries were due to civilian type low velocity handguns. A smaller percentage were due to intermediate type shotgun injuries which occurred predominantly during periods of political uprising during the early and mid 1980's. The majority of these injuries were purposefully and intentionally inflicted by others. Males within their third decade of life were most often the victims of these gunshot injuries. Most of these patients were of a lower socio–economic status and resided in the traditionally "Black" and "Coloured" residential areas.

The wounding effects of these low velocity injuries were characteristic, producing small rounded entrance wounds, causing fragmentation of teeth and comminution of the underlying bone, usually without any exit wounds. Mandibular fractures were more common than the maxillary ones with fracture patterns varying from simple to comminuted type fractures. The comminuted displaced type of fracture pattern, however, were most frequently observed.

The most common associated bodily injuries occurred to the head, neck and limb regions. Special investigations included plain film radiographs with more sophisticated investigations, e.g. CT–scans and angiograms being requested where indicated. Necessary airway

management was constituted where required and included emergency cricothyroidotomies, oral and nasal endotracheal intubations and elective tracheostomies. The vast majority of the patients, however, required no airway management.

The definitive surgical management was initiated by early soft tissue debridement (within 12–24 hrs). There was an equal distribution in both the early and delayed timing of the fracture management. Both the mandibular and maxillary fractures had more open than closed reductions done.

Bone continuity defects as a result of the initial injury were usually reconstructed secondarily using free antogenous bone grafts. This, however, comprised only of a smaller number of patients.

All the patients received anti–tetanus toxoid on admission and the majority received antibiotic treatment varying from one dose to a five to seven day course. This consisted of either penicillin alone or a combination of penicillin and metronidazole in most cases.

The mean hospitalization stay totalled six days. Most recorded complications presented early (within one week) post–injury. The most frequent recorded complications were sepsis, ocular and neurological complications and limitation of mouth opening.

The post–operative sepsis rate was high (19%). The common neurological complications consisted of varying degrees of damage to the facial and trigeminal nerves. Blindness was the most common ocular complication observed. Other complications included oro–antral, oro–nasal and parotid fistulae and bony and fibrous ankylosis. These, however, occurred less frequently.

It is, therefore, concluded that maxillofacial gunshot injuries are increasing in large urban populations. The wounding effects of these low velocity missile injuries are devastating and pose a treatment challenge to the maxillofacial surgeon.

ABSTRAK

Dit wil voorkom dat daar 'n verhoging in die gebruik van vuurwapens onder die bevolking van die Kaapse Metropilitaanse area is, wat 'n gevolglike verhoging in die aantal vuurwapen verwante sterftes veroorsaak het (Lerer *et al.*, 1997). Dus die doel van hierdie studie was derhalwe om die demografiese data, die patroon, handeling en komplikasies van vuurwapen beserings aan die gesig area te ondersoek.

Hierdie is 'n retrospektiewe studie van vuurwapen beserings aan die kaak en gesigs area wat oor 'n 15 jaar periode (1980–1995) behandel is. 'n Totaal van 301 gevalle was ondersoek.

Vuurwapen beserings aan die kake en gesig het oor die jare eksponensieël verhoog, met die meeste gevalle na 1990. Die meerderheid van hierdie beserings was as gevolg van lae spoed hand vuurwapens. 'n Klein persentasie was as gevolg van haalgeweer beserings, wat meestal tydens periodes van politieke onluste in die middel tagtige jare voorgekom het. Die meeste gevalle was doelbewus deur ander persone veroorsaak. Mans in die derde dekade was die meeste slagoffers van hierdie skietwonde. Die meeste van die pasiente was aan 'n laer sosio–ekonomiese stand en woonagtig in die tradisionele "Swart" en "Kleurling" woonbuurte.

Die beserings effek van hierdie lae spoed skietwonde was karakteristiek klein, ronde, ingangswonde met verbrokkeling van tande en die onderliggende been, gewoontlik sonder uitgangswonde. Mandibulâre frakture het meer algemeen voorgekom in vergelyking met maksillêre frakture, met die fraktuur tipe wat wissel van die eenvoudige tot die verblokkelde tipe fraktuur. Die verbrokkelde verplaasde tipe fraktuur patroon was die mees algemeen opgelet.

Die mees algemeen geassosieerde liggaam besering het aan die kop, nek en ledemate voorgekom. Spesiale ondersoeke het gewone X–straal fotos ingesluit, maar met die meer gevorderde ondersoek van byvoorbeeld komputer tomografie en angiografie, is dit aangevra

waar nodig. Hantering van die lugweg was ingesluit waar nodig en het krikotiroiedotomie, orale en nasale cudotrakeale intubasies en elektiewe trageostomies ingesluit. Die meerderheid van die pasiente het egter geen lugweg hantering benodig nie.

Die defintiewe chirurgiese hantering was begin deur vroeë sagte weefsel debridement (binne 12–24 uur). Daar was 'n gelyke verspryding van vroeë en laat hantering van frakture. Beide die mandibula en maksilla het meer oop as toe reduksies gehad.

Defekte in die kontinuteit van die been as gevolg van die aanvanklike besering was gewoonlik sekondêr herstel deur middel van vry antogene been oorplanting. Dit het egter net in 'n klein persentasie van pasiente voorgekom.

Al die pasiente het 'n anti–tetanus toksoied met toelating ontvang en die meerderheid het antibiotiese behandeling ontvang wat gewissel het van een dosis tot 'n vyf to sewe dag kursus. Dit het bestaan uit of penisillien alleen of 'n kombinasie van penisillien en metronidazol in die meeste gevalle.

Die gemiddelde hospitalisasie periode was ses dae. Die meeste komplikasies het vroeg voorgekom (binne een week). Die mees algemene komplikasie was sepsis, okulêre en neurologiese komplikasies en beperkte mond openinge.

Die insidensie van post–operatiewe sepsis was hoog (19%). Die algemene hemologiese komplikasies het bestaan uit verskye grade van uitval van die fasiale en trigeminale senuwees. Blindheid was die mees algemene okulêre komplikasies. Ander komplikasies het oro–antrale, oro–nasale en parotis fistulae en benige en fibreuse ankilosis ingesluit. Hierdie het egter minder gereeld voorgekom.

Dit is dus duidelik dat vuurwapen beserings van die gesig onder groot stedelike bevolkings besig is om te verhoog. Die beserings effekte van hierdie lae spoed missiel beserings is groot en hou groot uitdagings in vir die kaak–gesigs en mondchirurg.

TABLE OF CONTENTS

Page No.

LIST OF TABLES

LIST OF GRAPHS

Page No.

LIST OF FIGURES

Page No.

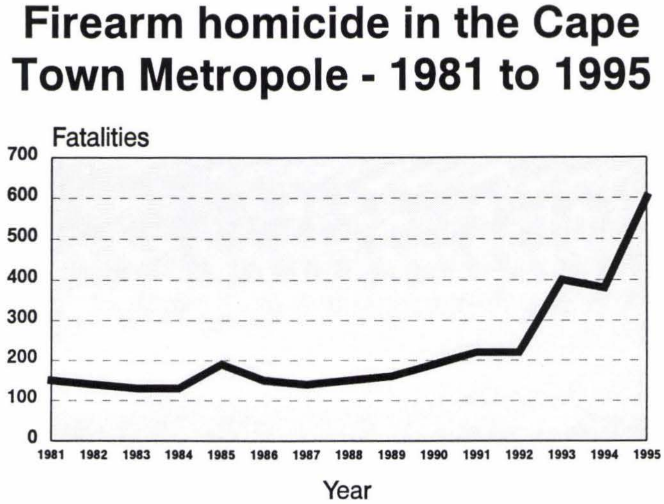
LIST OF DIAGRAMS

Page No.

1. INTRODUCTION

The earliest history of small firearms are closely related to the invention of gun powder around 1250 by Roger Bacon, an English monk (Sellier and Kneubuehl, 1994). Since then, through the centuries, more sophisticated arms and ammunition have been developed. This has resulted in a subsequent increase in the ownership of sophisticated weapons by the civilian population. Williams *et al.* (1988) and Kihtir *et al.* (1993) reported a steady increase in urban violence and attempted suicides in the United States with an increase in civilian handgun injuries to the face. This often results in devastating injuries to the face which pose a treatment challenge to the attending maxillofacial surgeons (Gussack *et al.*, 1988).

During the 1980's, gunshot injuries seen at Groote Schuur Hospital, Cape Town were often due to suicide attempts. In a recent study undertaken by the Medical Research Council (Lerer *et al.*, 1997) on violence and injury mortality in the Cape Town metropolitan area, there appears to be an increase in the use of handguns amongst the civilian population. They have reported that firearm related deaths in Cape Town have increased from less than 200 in 1991 to more than 600 in 1995 (refer Graph 1 below).



From their firearm related mortality statistics, it is apparent that the Western Cape is the most violent and crime–ridden province after Gauteng with the traditionally "Coloured" and "African"[1] residential areas being most commonly affected. Lerer *et al.* (1997) further reported that the murder rate in Cape Town was seven times higher than any other city in the United States.

The South African Safety and Security Minister, Sidney Mufamadi, reported that 19,600 South Africans with criminal records are presently registered firearm owners and 1,901 people who were declared unfit to possess firearms, are currently in possession of licensed firearms. Compounded with the harsh realities of the above mentioned statistics, gang and taxi warfare is rife in Cape Town (Lerer, 1997). The increase firearm ownership by the civilian population (Natal Witness, 1997), compounded by increasing crime rate in Cape Town (Cape Times, 1996; Lerer, 1997), facial gunshot injuries in Cape Town appear to be increasing exponentially over the years (Fleming *et al.*, 1993). This criminal violence has a deleterious impact on our local health care system by imposing further financial burden on our limited health care budget (Lerer *et al.*, 1997).

Thus far, local studies have concentrated on the mortality of gunshot injuries (Veller and Green, 1984; Lerer *et al.*, 1997). Less information is available of people who survive gunshot injuries, especially in the Cape Town area.

[1]Prior to 1994, the people of South Africa were classified according to the Population Registration Act of 1950. Residential areas were created according to the Group Areas Act of 1950. The use of these terms do not imply their legitimacy.

The American literature reviewed (Yao *et al.*, 1972; Joy, 1973; May, 1973; Gant *et al.*, 1979; Finch *et al.*, 1979; Gussack *et al.*, 1988; Williams *et al.*, 1988; Haug, 1989; Neupert III *et al.*, 1991; Dolin *et al.*, 1992; Thorne, 1992; Kihtir *et al.*, 1993) have reported on isolated case studies of low velocity type gunshot injuries to the face. Studies of maxillofacial gunshot injuries from other first world countries (e.g. Britain and the United States of America) have been scant and concentrates on wartime higher velocity type injuries (Rowe and Williams, 1985; Fonseca and Walker, 1991).

These studies have concentrated on ballistic principles, hard and soft tissue injuries, short and long term complications and various management aspects. Little has been reported on the demography and prevalence of civilian lower velocity type injuries. The overall sample sizes of the cases of lower velocity type injuries were small (less than one hundred), thus making the results statistically less valuable.

It is evident that with the increase in prevalence of maxillofacial gunshot injuries seen in Cape Town (Fleming *et al.*, 1993), firearm violence is becoming a serious public health and economic problem. The management of these patients often require multiple, complex, secondary treatment procedures to achieve a satisfactory functional and aesthetic result. In addition, there are severe psychological effects that the resulting facial disfigurement can have on the patient (Laskin, 1994).

Considering the shortcomings noted in the literature reviewed, and that the management of these injuries form an important aspect of the training of maxillofacial and oral surgeons, this study will review aspects of maxillofacial gunshot injuries seen and treated at Groote Schuur Hospital, Cape Town. The prevalence, demographics, frequency and patterns of hard and soft tissue injuries, management aspects as well as short and long term complications of 301 cases over a 15 year period ranging from 1980 to 1995 will be reviewed.

2. LITERATURE REVIEW

The literature review presented summarizes information regarding ballistics, prevalence and demographic data, and different aspects including surgical management as well as complications of both low and high velocity gunshot injuries to the maxillofacial region.

2.1 CLASSIFICATION OF BULLETS AND FIREARMS

Weapons responsible for civilian injuries are usually handguns (pistols) or rifles (Fonseca and Walker, 1991). The **"calibre"** of a weapon refers to the diameter of a bullet or rifle bore in hundredths or thousands of an inch (Swan and Swan, 1991).

Handguns or **pistols** are classified as **low velocity** weapons. These range from 0.22 to 0.45 calibre with a muzzle velocity ranging from 700 to 1000 feet/second. Magnum handguns deliver 20 to 60 percent more energy than the handgun equivalent because of the higher velocity attained from increasing the powder charge (Holt and Kostohryz, 1983).

The **rifle** is a shoulder braced firearm developed to produce maximum energy. These weapons are so called because of their "spiral or rifling grooves" cut into the barrel causing the bullet to spin thereby increasing its flight stability, its range, and accuracy (Fonseca and Walker, 1991).

Shotguns are smooth bored guns primarily designed for game hunting. Their chamber pressures, muzzle velocities are low and the effective range is short (Fonseca and Walker, 1991). The shotgun missile consists of a large number of pellets that are widely dispersed when fired resulting in a degradation of its kinetic energy. This decreases its potential wounding capacity except if vital organs (e.g. the eye) is damaged (Swan and Swan, 1991). The "sawed off" variety is most commonly used by law enforcement officers during riots or by criminals and has a more rapid dispersion of pellets, thus increasing the probability of it hitting its target. The **gauge** indicates the diameter of the shotgun bore and its corresponding cartridge or shell. This is normally measured in hundredths or thousandths of an inch and are usually expressed in gauge numbers, ranging from 12 (largest) to 410 (smallest). Twelve (0.729 inches) and twenty (0.615 inches) are the most common gauges used (Swan and Swan, 1991; Fonseca and Walker, 1991).

Firearm projectiles are referred to as **bullets**. The modern bullet is usually a lead projectile covered partially or completely encased in a copper jacket. The fully jacketed bullets travels longer distances with more accuracy due to its aerodynamic shape. The copper jacket also decreases the deformation of the bullet thereby minimizing its effective wounding capacity. (Holt and Kostohryz, 1983; Fonseca and Walker, 1991). The fully jacketed bullets are the only ones approved by the **Hague Convention**[2] for use in military combat. Expanding bullets also referred to as hollow point, soft nose or dum–dum bullets are semi–jacketed with an exposed lead tip. These bullets deform in a predictable manner, expanding on entering tissue and thereby increasing the wounding capacity. These bullets are avoided for combat purposes as dictated to by the **Hague Convention**[2] . The soft lead tip may fragment causing extensive damage. These bullets can be used by law enforcement officers or civilians.

[2]Hague Convention (1899) – A peace convention centred around the restriction of armaments. The restriction on small arms and amunition read: "The contracting parties agree to abstain from the use of bullets which expand or flatten easily in the human body, such as bullets with a hard envelope which does not entirely cover the core or is pierced with incisions."

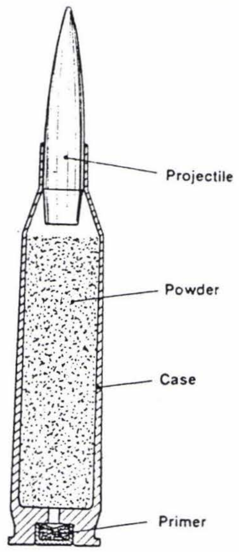
Bullet velocities are classified as **low**, under 1000 feet/second, **medium**, between 1000 and 2000 feet/second, and **high**, above 3000 feet/second (Rowe and Williams, 1985). Missiles travelling in excess of 35000 feet/second are considered as **ultrahigh velocity** (Fonseca and Walker, 1991). Shotgun missiles travel at a velocity of approximately 1200 feet/second, therefore are of an **intermediate velocity** (Zide and Epker, 1979).

2.2 BALLISTICS

Ballistics is the study of the motion a projectile acquires during its travel through the barrel of a firearm [**internal ballistics**], its trajectory through the air [**external ballistics**], and after striking the target [**terminal or wound ballistics**] (Fonseca and Walker, 1991).

Internal Ballistics considers the conversion of chemical energy of the propellant (gunpowder) to the kinetic energy of the bullet (Swan and Swan, 1991). The cartridge comprising the primer, gunpowder and projectile is loaded into the chamber at the breech end of the gun barrel. The primer is struck mechanically which ignites a spark, burning the gunpowder and consequently causing acceleration of the projectile **(refer to diagram 1 adapted from Sellier and Kneubuehl, 1994).**

Diagram 1: Main parts of a cartridge



External Ballistics refers to the trajectory of the missile through the air and has a direct effect on the wounding capacity (Fonseca and Walker, 1991).

Wound Ballistics refers to the amount of kinetic energy (K) imparted from a missile to its target which is directly related to the mass (M) and the velocity (V) of the projectile as follows:—

$$K = \frac{MV^2}{2}$$

Since the velocity is squared in the formula, it represents the greatest contribution to the energy transferred (Gant and Epstein, 1979). When a missile does not exit, then it imparts all its energy within its target tissue. If a missile exits, the energy transferred is expressed by the formula:—

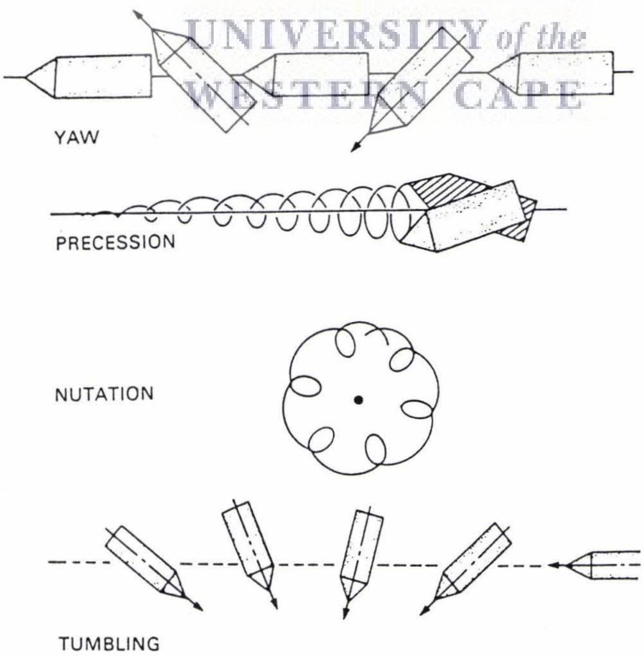
$$K = \frac{M(V_1 - V_2)^2}{2}$$

Where V_1 is the impact velocity and V_2 is the exiting velocity (Holt and Kostohryz, 1983).

The wounding capacity of a missile is also determined by distance of the target; i.e. at distances beyond 1000 yards, the impact velocity and wounding capability is reduced (Haug, 1989; Fonseca and Walker, 1991). The shape of a missile affects the wounding capacity as well. A full jacketed bullet travels longer distances and is more accurate than a "dum–dum" bullet which deforms on impact, thereby increasing its tissue contact. The energy released is enhanced thereby causing more damage. These type of bullets are less likely to exit from the target. Jacketed bullets are more likely to fragment on impact (Holt and Kostohryz, 1983; Cohen, 1984; Fonseca and Walker, 1991).

In a bullet, the centre of gravity lies behind the nose of a bullet. The oscillation around the long axis of a bullet is referred to as the **"yaw"**. This determines the initial injury in terminal ballistics (Haug, 1989). The spin imparted by "rifling" of a bullet induces other forms of motion such as **precession** and **mutation**. **Precession** is a circular form of yawing around the centre of gravity that takes the shape of a decreasing spiral. **Mutation** is a rotational movement in small circles that forms a rosette pattern like a spinning top. These movements help stabilize a bullet in flight, and becomes unstable upon striking its target. When a bullet has lost much of its velocity in flight, it may tumble. **Tumbling** is defined as the forward rotation of a bullet around the centre of its mass (Swan and Swan, 1991; Fonseca and Walker, 1991) **(refer to diagram 2 adapted from Fonseca and Walker, 1991)**.

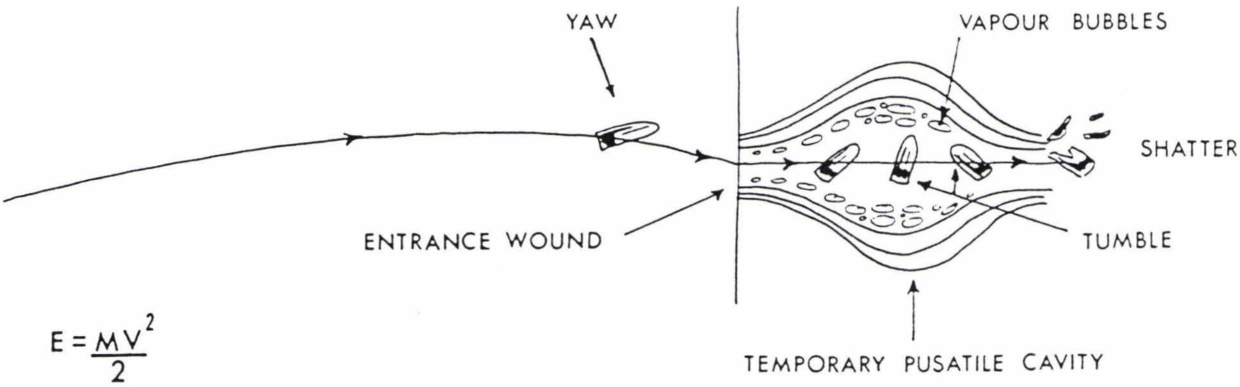
Diagram 2: Variation in the motion of bullets



A bullet striking with a large degree of yaw will have an increased surface of presentation with a greater expenditure of energy over a shorter distance (Holt and Kostohryz, 1983). A non–tumbling or yawing bullet will hit its target at right angles and will have less tissue contact than one striking at an oblique angle thereby remaining more stable (Fonseca and Walker, 1991).

When a missile of sufficient energy enters the tissue, a temporary pulsatile cavity is formed. This is due to pressure waves which are transmitted perpendicular to the path of the bullet. This temporary cavity can be as large as 30 to 40 times the diameter of the bullet and is often of a short duration (5 to 10 m/second). Superimposed on these pressure waves are shock waves which are directly related to the velocity of the missile. The cavity created by the missile rapidly collapses behind the projectile because of tissue elasticity, haemorrhage and oedema, leaving a smaller permanent pathway or cavity. The pulsatile activity of the temporary cavity draws powder, clothing, skin fragments and bacteria along with the projectile. This cavity is therefore contaminated (Gant and Epstein, 1979; Holt and Kostohryz, 1983; Haug, 1989; Swan and Swan, 1991). (Refer to diagram 3 adapted from Rowe and Williams, 1985).

Diagram 3: Pathway of a bullet tract



$$E = \frac{MV^2}{2}$$

Thus, the wounding capacity of a bullet is directly related to the energy transferred by the bullet to the surrounding tissue with the velocity being the most important parameter. Other factors such as bullet mass, material from which the bullet is constructed, the yaw and tumble of the missile and the density of the target tissue will all affect the subsequent injuries caused (Gant and Epstein, 1979; Holt and Kostohryz, 1983).

2.3 PREVALENCE AND DEMOGRAPHIC CHARACTERISTICS OF GUNSHOT INJURIES

Numerous local and international studies have reported the overall prevalence of gunshot injuries to be increasing in large urban populations (Yao *et al.*, 1972; Shuck *et al.*, 1980; Cohen, 1984; Veller and Green, 1984; Nelson *et al.*, 1986; Williams *et al.*, 1988; Haug, 1989; Fleming *et al.*, 1993 and Laskin, 1994).

Although missile injuries to the face are relatively uncommon, their overall prevalence amongst the civilian population appears to be increasing. These injuries pose both an immediate threat to life and may produce delayed complications such as infection and cosmetic problems (Yao *et al.*, 1972; Cohen, 1984; Rowe and Williams, 1985; Haug, 1989; Fleming *et al.*, 1993 and Laskin, 1994).

A recent study undertaken by Lerer *et al.* (1997) at the Medical Research Council have reported the overall mortality of firearm related injuries including their prevalence and demographics in the Cape Town metropolitan area during 1994 and 1995. They have highlighted the fact that homicides and suicides related to firearms, contribute substantially to the burden of disease especially amongst the poor and disadvantaged communities in South Africa. Their study has also raised the issue of injury control awareness as a health priority in the Western Cape. The firearm related mortality statistics within Cape Town for 1995 shows that:—

(a) Homicide is the leading cause of non–natural death in the "Black" and "Coloured" populations in Cape Town. Of the 1962 homicide deaths reported, 626 (32%) were due to firearms.

(b) Suicide is a major cause of non–natural mortality amongst the "White" population, accounting for 121 (33%) of deaths. Firearms were used in 38% of these suicides.

(c) Adolescents and young adults were most often the victims of firearm related mortalities.

(d) Firearm related homicide mortalities occurred most frequently in the lower socio–economic areas.

Few South African studies have reported the prevalence and isolated demographic data relating to maxillofacial gunshot injuries (Cohen, 1984; Fleming *et al.*, 1993 and Tsakiris *et al.*, 1996). Their results show that males within the third decade of life were most frequently affected. The socio–economic status of the patients studied was not reported.

Nelson *et al.* (1987) in their study reported that the United States has the highest incidence of firearm related violence in the Western "civilized" world. They also reported that before an accurate assessment of aetiology can be made, an improved awareness of the incidence and financial as well as emotional loss of the firearm violence is necessary. They noted that handguns were most commonly used, young males from a lower socio–economic background were most often the victims of attacks and older males were involved in suicide attacks more frequently. Sex, region of the country, age of first shooting experience were important demographic factors studied to highlight the socialization aspect of firearms.

The rest of the international literature reviewed (Yao *et al.*, 1972; May *et al.*, 1973; Shuck *et al.*, 1980; Banks, 1985; Gussack and Jurkovich, 1988; Nelson *et al.*, 1987; Haug, 1989; Neupert *et al.*, 1991; Fonseca and Walker, 1991; Dolin *et al.*, 1992; Kihtir *et al.*, 1993; Laskin, 1994) both during wartime and peacetime indicate that males within their third decade of life were most often the victims of facial gunshot injuries. These international studies, however, failed to mention the relative income status of the victims or the assailants.

2.4 VELOCITY AND CALIBRE OF WEAPONS

The local (Cohen, 1984; Veller and Green, 1984) and international (Yao *et al.*, 1972; Joy, 1973; May *et al.*, 1973; Gant and Epstein, 1979; Rowe and Williams, 1985; Williams *et al.*, 1988; Haug, 1989; Kihtir *et al.*, 1993) literature regarding maxillofacial gunshot injuries during peacetime are caused by low calibre, low velocity handguns. Wartime military experience showed that intermediate and higher velocity–type weapons were used (Rowe and Williams, 1985). Cohen (1984) in his study indicated that most handguns ranged from 0.22 to 9mm calibre–type weapons, with the 0.38 calibre bullet being most often used.

2.5 SOFT AND HARD TISSUE INJURIES

There are relatively few reports in the literature which deal with civilian gunshot wounds of the face by low velocity bullets from handguns (Kihtir *et al.*, 1993). The amount of tissue injury produced by low velocity missiles is considerably less than those resulting from higher velocity type missiles. This is an important consideration in the management of these injuries (Yao *et al.*, 1972; May *et al.*, 1973; Gussack and Jurkovich, 1988; Kihtir *et al.*, 1993). In describing the ensuring injuries resulting from gunshot wounds to the face, one must consider that the maxillofacial region comprises of a complex anatomical arrangement of bone and soft tissue containing many important structures. The bony framework of the facial skeleton is comprised of twenty individual units, each with a particular function. Numerous blood vessels and a variety of vital organs are present in this area. Missile injuries may therefore involve any number of structures causing a variable extent of damage (Cohen, 1984).

To understand the type of hard and soft tissue injuries produced, one has to consider the principles of wounding ballistics. The civilian handgun discharges a missile that is composed of lead or a lead alloy and may have a round, blunt or hollow tip. The amount of velocity upon discharge of the weapon is dependant upon the amount of charge within the shell of the bullet. As the missile leaves the handgun, it travels in an arc and deviates from its original line of fire. This deviation may be by spiralling, twisting, or tumbling. The yaw, or angle of travel, determines the initial injury in terminal ballistics. The wounding capacity is related to the kinetic energy produced which is in turn related to the mass and the velocity. When a missile does not exit, then it imparts all its energy within the target tissue (Holt and Kostohryz, 1983; Haug, 1989; Fonseca and Walker, 1991).

By definition, low velocity bullets travel at a speed less than 1000 feet per second, and lacerate and crush the tissues through which they pass. The surrounding structures are not usually affected, and the injuries are not usually serious unless a vital structure is directly involved. Both the entry wound and the residual channel are usually smaller than the diameter of the missile due to the elastic recoil of the tissue. There is usually no exit wound (Gant and Epstein, 1979; Gussack and Jurkovich, 1988; Haug, 1989; Neupert III *et al.*, 1991; Kihtir *et al.*, 1993).

The other major determinants in the wounding mechanism of low velocity gunshot injuries from a ballistics perspective include distance travelled by the missile (i.e. the range at which the injury occurred), fragmentation or deformation of the projectile, muzzle velocity versus the terminal velocity including the calibre of the weapon and the bullet yaw while penetrating the tissue (Neupert III *et al.*, 1991).

The initial cutaneous wound is dependant upon the yaw at impact. Within one to two milliseconds after the impact, a pressure wave from the air in front of the missile distends the tissues temporarily. This temporary cavity is up to four times the diameter of the missile in low velocity injuries and is usually fusiform in shape (Gant and Epstein, 1979). This pulsatile shock can produce injury at a distance from the path of the bullet. Low velocity projectiles follow facial planes and not in straight lines and may be found in unexpected locations. Pulsation of the temporary cavity sucks bacteria into the wound. The permanent cavity or the bullet tract therefore contains skin, clothing, necrotic tissue and secondary projectiles and is generally slightly larger than the calibre of the projectiles. The projectile may encounter dense non–elastic tissues and transform them into secondary projectile. Therefore, the wounding capacity of a missile is related to its kinetic energy.

Fonseca and Walker (1991), classified gunshot injuries according to their clinical appearance. They categorized these wounds into:—

(a) **Penetrating Wounds —** These are typically caused by low velocity missiles. Here the missile is usually retained within the tissue indicating that the tissues have absorbed and dissipated all its kinetic energy. The entrance wounds here are typically small rounded and ragged. As the missile penetrates, the tissues are usually crushed and forced apart. Usually, only the tissues in direct contact with the missile are struck. When the hard tissues are struck, fracture and comminution with possible displacement occurs. Here vital structures such as nerves and blood vessels may be damaged without direct contact by the bullet.

(b) **Perforating Wounds —** These are wounds caused by missiles with higher velocities e.g. close range shotgun injuries and magnum type handguns. Here the missile usually passes completely through its target causing both entrance and exit wounds. Here the entrance wounds are comparable to the size of the bullet with the exit wounds being considerably larger. This is due to the fact that when the missile strikes teeth and bone, it often causes secondary fragmentation which causes widespread tissue destruction and a larger exit wound.

(c) **Avulsive Wound —** These are usually caused by high velocity rifle missiles, artillery or mortar fragments. These are large, gaping avulsive type wounds with larger areas of tissue loss.

One also has to consider the wounding effects of hollow–point and dum–dum bullets which are becoming increasingly more popular due to their destructive wounding effects. Both these missiles deform on impact and usually do not cause exit wounds. The dum–dum bullet is a homogenous flat nosed cylindrical structure designed for firing from a rifle. This becomes grossly distorted on impact. These can cause avulsive type entrance wounds. The hollow–point bullet is fired from a pistol at low velocity with only the exposed dimpled tip flattening on impact causing less severe wounding effects compared to the dum–dum bullet (Haug, 1989).

According to Haug (1989) the following wounding effects of low velocity missiles upon both hard and soft tissue were observed:—

(a) **Skin —** The projectile requires a minimum velocity of 50 to 70 meters per second to enter the skin. Generally, the entrance wounds are smaller than the diameter of the bullet and normally range from circular to oblong depending on the yaw. If there is significant deformation of the projectile before or on impact, the cutaneous surface is usually bevelled at an angle converging to the permanent cavity. This bevelled wound represents abraded epidermis and dermis. Grossly, these entrance wounds with surrounding contusion, abrasion and particulate matter within them. At closer range, burns or tattooing of the cutaneous layer by the projectile shavings or residue occur. The exit wounds, when occurring, are usually stellate or slit–like.

(b) **Muscle —** The injury pattern within the muscle is usually due to the behaviour of the temporary cavity. The muscle layer is usually elastic and deforms easily, up to four times the diameter of the missile. There is usually powder, clothing, skin fragments and bacteria dragged along with the projectile. The pulsatile activity of this temporary cavity further draws additional material into the wound (Fonseca and Walker, 1991). A critical level of 10^5 bacterial concentration per gram of muscle may be present within six hours of the injury.

(c) **Vasculature** — Blood vessels are usually damaged by direct contact with the missile causing subsequent crushing, lacerating or stretching type injuries upon them. They may also be displaced by the temporary cavity. This may result in vascular shear, arterial spasm, haematoma formation, haemorrhage, thrombi or pseudanocrysin formation.

(d) **Nerve** — The cause of the nerve injury is similar to that of the vasculature. This results in hyperaesthesia, anaesthesia, paraesthesia and motor conduction defects may be noted. In low velocity injuries, most neuropathies returns to normality spontaneously.

(e) **Bone** — Bone is unelastic with the critical velocity causing fracture being 65 meters per second. Generally, low velocity injuries cause comminution of the cortical bone and drill type hole defects in the cancellous bone. The comminuted bone particles often becomes secondary projectiles which are displaced into the permanent cavity or lost into the mouth. Sometimes, the pressure wave caused by the temporary cavity may crack the cortical bone although this is rare in low velocity type projectiles.

(f) **Teeth** — The teeth are often shattered with the shattered particles becoming secondary projectiles which are displaced into the permanent cavity. These fragments together with the shattered unpedicled bony fragments become displaced into the mouth or sometimes displaced elsewhere, e.g. pharynx and can be aspirated. Therefore it is mandatory that a careful clinical examination should be undertaken to locate these fragments.

2.6 SHOTGUN INJURIES

In these injuries, the size of the wounding pattern obviously changes with the distance between the muzzle and the target. A choke normally exists at the end of a shotgun muzzle which acts like a nozzle of a hose to control the scatter pattern of the pellets (Zide and Epker, 1979). According to the aforementioned authors, most shotgun injuries to humans occur at a range of less than ten yards. They have also noticed that:—

(a) At close range, up to approximately one feet, a single entrance wound up to two inches in diameter with jagged edges would be produced. These wounds are surrounded with powder burns.

(b) At intermediate range (between four to six feet), the wound is approximately two inches in size with scalloped margins and separation of the pellets are noticed.

(c) At further ranges, the entrance wounds are often multiple small rounded areas, usually dependant upon the size of the pellets. Wide dispersion can also be produced within the body in spite of a small entrance wound. The dispersion of the pellets is also due to the deflection of these pellets against the hard tissues. At greater distances, however, each shot has an individual trajectory and entrance, distant from the pathways of the neighbouring pellets.

2.7 SITE OF ENTRANCE AND EXIT WOUNDS

Kihtir *et al.* (1993) in their study, grouped the facial gunshot injuries into three anatomic areas:—

(a) **Lower Face** – comprising the mandibular and tongue areas.

(b) **Midface** – the maxilla, lower part of the nose and the zygomatic areas.

(c) **Orbital** – including the orbital area and nasoethmoidal complex area.

In their study, most entrance wounds were located within the midfacial region. Other authors (Gant and Epstein, 1979; Gussack and Jurkovich, 1988), also described the entrance and exit wounds located to similar anatomical areas described by Kihtir *et al.* (1993), although they included intracranial injuries whereas Kihtir *et al.* (1993) excluded all injuries above the orbital areas.

2.8 TYPE OF FRACTURES

Cohen (1984) proposed a classification of low velocity handgun injuries of the maxillofacial region into:—

Type I – soft tissue injury alone.

Type II – single fracture without comminution.

Type III – single fracture with localized comminution of the fracture site.

Type IV – severe comminution of a large area of bone.

Suffix S – associated significant soft tissue injury; e.g. Type IIIs would be a single fracture with localized comminution of the fracture site with a significant soft tissue injury.

May *et al.* (1973) in their study of twenty cases of mandibular fractures from civilian gunshot wounds, classified their fractures into displaced and undisplaced types with the displaced type occurring in eighteen of the twenty cases.

Fleming *et al.* (1993) in their study, refer to the fracture patterns as being either simple or complex type fractures. The complex displaced type fractures were more common.

Williams *et al.* (1988) refer to the mandibular fractures as being either favourable or unfavourable with or without displacement. The unfavourable type fractures were more frequent.

Most other studies of low velocity facial gunshot injuries, do not mention the degree of displacement of the fractures present other than referring to them as being either simple or comminuted type fractures (Gant and Epstein, 1979; Rowe and Williams, 1985; Haug, 1989; Fonseca and Walker, 1991; Kihtir *et al.*, 1993; Tsakiris *et al.*, 1996).

2.9 CLASSIFICATION OF LOW VELOCITY GUNSHOT INJURIES TO THE MAXILLOFACIAL REGION

Classifications of injuries are useful to clinicians in that communication regarding injuries may be simplified and therefore more easily understood. Various attempts have been made in order to classify maxillofacial gunshot injuries. The overall aim of these classifications have been to simplify treatment protocols of these complex injuries. These classifications were aimed at the traumatologist being able to identify areas of importance in the maxillofacial region in order to undertake certain special investigations more astutely and making appropriate referrals more efficiently.

Saletta *et al.* (1976), studied penetrating injuries to the neck and described three zones of the neck namely I, II and III. Zone III refers to the area of the neck above the angle of the mandible. This classification is commonly employed for penetrating neck injuries seen at Groote Schuur Hospital's Trauma Unit. Dolin *et al.* (1992) in their study of the management of facial gunshot wounds routinely performed angiography on those patients whose injuries traverse all three zones of the neck as described by Saletta *et al.* (1976). This classification, however, refers only to the neck region and does not include injuries to the face.

In the study of Gant and Epstein (1979), injuries were categorized according to the area of entry of the missile. Area I was described as the supraorbital area involving the frontal bone and the cranium, area II as the midface between the supraorbital ridges and the upper lip and area III as the lower lip the hyoid bone. For descriptive purposes, this classification does not describe the extent of the injuries sustained.

Fonseca and Walker (1991), and Rowe and Williams (1985) classified gunshot injuries according to their wounding affects. These were described into: (1) Penetrating; (2) Perforating; and (3) Avulsive type wounds. These wounds were elaborated on in the discussion of soft tissue injuries. This classification, however, merely describes the wound and not the missile trait and its relation to the vital structures. The extent of the injury is not described here.

Zide and Epker (1979), in their study of shotgun wounds to the face, referred to the range at which the injuries occurred; namely, far range, intermediate and close or point blank range. This classification, however, does not apply to injuries caused by low velocity missiles but does pose a logical and practical approach to facial gunshot injuries.

Cohen (1984) proposed a logical classification to maxillofacial gunshot injuries as described previously. This classification, however, describes the type of hard and soft injuries inflicted but excludes the relative anatomical areas involved and the range at which the injuries occurred.

It is evident that no satisfactory classification of maxillofacial gunshot injuries exists and therefore for the purposes of the present study a combination of the above classification systems was applied. The exact location and type of hard and soft tissue injuries were applied.

2.10 ASSOCIATED INJURIES

Associated bodily injuries that present with concomitant maxillofacial gunshot injuries are variable (Rowe and Williams, 1985). These authors also state that a closed head injury should be suspected when facial gunshot injuries involve the mid and upper facial regions. Kihtir *et al.* (1993), in their study reported intracranial injury as being the most common associated injury with remote organ injury being less frequent. The severity of the neurological compromise can vary from a closed head injury with a depressed level of consciousness to permanent neurological damage. This often depends on the path of the missile or from the shock wave produced by the temporary cavity (Gant and Epstein, 1979; Rowe and Williams, 1985).

2.11 SPECIAL INVESTIGATIONS

Most of the local and international literature reviewed (Yao *et al.*, 1972; Gant and Epstein, 1979; Cohen, 1984; Rowe and Williams, 1985; Gussack and Jurkovich, 1986, Fonseca and Walker, 1991; Dolin *et al.*, 1992) agree that plain film radiographs together with a thorough clinical examination often indicated the trajectory of the bullet. The initial management usually focused on airway management and ventilation followed by arrest of any haemorrhage. Standard plain film radiographs which include skull, facial and cervical spine radiographs are usually then employed. More complex special investigations e.g. computer tomography scans and angiography are requested where indicated. Carotid angiograms are requested where a vascular injury is suspected and computer tomography scans are a necessity with associated intracranial injuries or complex facial fractures (Yao *et al.*, 1972; Rowe and Williams, 1985; Fonseca and Walker, 1991; Dolin *et al.*, 1992; Kihtir *et al.*, 1993).

2.12 TREATMENT PRINCIPLES AND COMPLICATIONS

Much of our present knowledge regarding management of gunshot wounds has been gained from wartime military experience. These concern higher velocity, avulsion type wounds with severe hard and soft tissue loss and destruction. In contrast, firearm injuries encountered by the traumatologist in peacetime, are produced by low calibre, low velocity handguns which produce less devastating injuries to the maxillofacial complex (Rowe and Williams, 1985; Haug, 1989; Gant and Epstein, 1979; May *et al.*, 1973; Joy, 1973; Williams *et al.*, 1988; Kihtir *et al.*, 1993; Yao *et al.*, 1972).

Very few South African studies of maxillofacial gunshot injuries have been reported. Cohen (1984) studied forty cases of low velocity handgun injuries seen at the teaching hospitals in Gauteng. Tsakiris *et al.* (1996) did a retrospective study of 211 maxillofacial gunshot injuries treated at the *Department of Maxillofacial and Oral Surgery of the University of the Witwatersrand, Gauteng* between 1987 to 1992. The studies by Cohen (1984) and Tsakiris *et al.* (based on 93 completed cases) (1996), show similar findings. They found most injuries were due to low velocity civilian handgun type injuries and mandibular fractures were more common than maxillary ones. Airway protection requiring endotracheal intubation or tracheostomies was reported in 33.9% of patients (Tsakiris *et al.*, 1996) especially in those cases affecting the lower third of the face and neck. The fractures were mostly comminuted type fractures. These were treated conservatively by closed reduction and intermaxillary fixations. The most common reported complications in both studies were sepsis and bony and soft tissue residual defects.

One local study undertaken by Fleming *et al.* (1993) reported on 39 cases of maxillofacial gunshot injuries seen at Groote Schuur Hospital, Cape Town. Their results were similar to the above mentioned ones.

During 1983, the number of South African people shot by the police alone was in excess of 579 with 211 deaths (The Star Newspaper, 1983). During 1982, Veller and Green reported on 118 patients sustaining gunshot injuries seen at the Johannesburg hospital. These were mostly handgun injuries affecting the body. Thirty–eight cases were accidental, 28 due to suicide and 45 due to assault. They reported 23 fatalities.

The international literature reviewed over the last decade concerning low velocity facial gunshot injuries have been mostly North American studies. These are retrospective case reports undertaken at different centres over a short period ranging from one to five year intervals. The sample sizes were usually less than one hundred. These studies generally reviewed the initial presentation, types of hard and soft tissue injuries, ballistic studies, different management protocols and types of complications experienced. No long term retrospective or prospective studies have been reported (Yao *et al.*, 1972; May *et al.*, 1973; Joy, 1973; Gant and Epstein, 1979; Gussack and Jurkovich, 1988; Williams *et al.*, 1988; Haug, 1989; Neupert and Boyd, 1991; Dolin *et al.*, 1992; Thorne, 1992; Kihtir *et al.*, 1993; Finn, 1996).

The studies undertaken emphasized the principles of initial management of gunshot injuries to the face, namely maintenance of airway, control of haemorrhage and the treatment of shock. Thereafter, a more definitive plan of presenting injuries were made (Joy, 1973; Yao *et al.*, 1972; Gant and Epstein, 1979; Dolin *et al.*, 1992).

Yao *et al.* (1972) in their study of 60 missile injuries to the face over a four year period at Chicago and New York hospitals managed their mandibular and maxillary fractures conservatively (i.e. by closed reductions with intermaxillary fixations). The soft tissue injuries were debrided early and closed primarily. They also stated that close range shotgun injuries caused extensive damage and required extensive debridement with primary closure where possible. Secondary closure with split skin grafts to the exposed wounds were undertaken at a later stage. The reported incidence of sepsis was low and antibiotic coverage and prophylactic tetanus toxoid was also used.

May *et al.* (1973) reported 20 cases of mandibular fractures caused by handgun injuries. Most of the fractures were displaced and were generally treated by means of closed reductions. They also reported airway obstruction occurring in six out of twenty cases, necessitating tracheostomies.

Gant and Epstein (1979) reviewed 66 cases of low velocity gunshot wounds treated in San Francisco between 1971 and 1978. Their general principles of management were similar to those studies described above. They also emphasized that arteriographic studies were indicated where vascular damage was evident. There were four reported cases of sepsis post treatment noted.

Gussack and Jurkovich (1988) reported on a small series of 16 cases of low velocity injuries treated at a South Alabama trauma centre over a one year period. They present a well planned management protocol to avoid any missed injuries. The diagnosis of these injuries included plain film radiographs of the skull, cervical spine and facial bones. This also included arteriography, endoscopic examination, barium studies, computerized tomography and detailed ophthalmological examinations where indicated.

Neupert and Boyd (1991) undertook a retrospective analysis of 32 low velocity mandibular gunshot injuries treated at Parkland Memorial Hospital in Dallas. His findings were similar to those reported by May *et al.* (1973), except that they treated fractures of the condyle, ramus and coronoid process conservatively. Fractures of the angle, body and symphysis were treated mostly by means of open reductions. More cases of infection were reported in the latter group.

From the earlier literature reviewed (Joy, 1973; Zide and Epker, 1979; Banks, 1985), the management of severe gunshot injuries to the face produced by high velocity rifles and shotgun blasts always presented a challenge to the reconstructive surgeon (Gruss, 1990). Traditionally, the management of these wounds involved initial debridement and closure of the soft tissues combined with external fixation of the remaining maxillary and mandibular bony segments. The definitive bone replacement was usually delayed until the soft tissue replacement was completed. This approach usually caused an inability to maintain midfacial soft tissue expansion with the loss of the supporting underlying bony structure (Gruss *et al.*, 1991).

Very few European studies have been undertaken regarding lower velocity type injuries. Much of their experience have been eluded to by the English studies done during the Northern Ireland civil war reported by Rowe and Williams (1985).

The English literature revolves around higher velocity gunshot injuries experienced during the First and Second World Wars and principles of management of these wounds were outlined by Peter Banks in Rowe and William's (1985) book on maxillofacial injuries.

These wounds are more complex due to the ballistic principles of high velocity injuries. These wounds are managed by extensive initial debridement, removal of all unpedicled bone and teeth fragment and open packing with Whitehead's varnish packs or BIPP (Bismuth Iodine Paraffin Packs). Much of the bony reconstruction was done at a secondary stage. Extensive reconstruction of the soft tissue (intra– and extra–oral) defects was accomplished by various local and distant flaps (Rowe and Williams, 1985).

Recently over the last decade, with the advancement of technology and advent of more sophisticated antibiotics, diagnosis and management of gunshot wounds, both high and low velocity wounds has changed with lower complication rates reported. This is, however, still controversial, since cost–effectiveness is of importance. Compromises are then required in the interest of the patient's overall care (Thorne, 1992).

The treatment of complex facial fractures has been facilitated by the use of craniofacial surgical techniques, extended open reduction, rigid internal fixation with plates and screws and the replacement of severely damaged or missing bone with immediate bone grafting techniques (Gruss *et al.*, 1991). The use of microvascular free or pedicled osseous, osseocutaneous and myocutaneous flaps have further enhanced the overall success in the treatment of these devastating injuries (Rowe and Williams, 1985).

Manson (1985); Finch and Dibbell (1979); Gruss (1990); Gruss *et al.* (1991); Vásconez *et al.* (1996) all support the idea of primary soft and hard tissue reconstruction of higher velocity type gunshot injuries. Their experience confirms that this approach is safe, provides improved function, superior aesthetic results and earlier rehabilitation with decreased periods of disability.

Thorne (1992) recommended early definitive soft and bone reconstruction for lower velocity injuries. Although he recognized that later bone reconstruction with bone grafting has lower infectious complications than initial bone reconstruction, the earlier soft tissue reconstruction produces scar contracture, thus making secondary bone grafting more complicated.

Gruss *et al.* (1991) treated 37 patients at the Sunnyside Medical Centre in Toronto, Canada who sustained high velocity gunshot injuries to the face with early definitive bone and soft tissue reconstruction. He placed a total of 177 primary bone grafts in 33 patients for orbital, nasal, zygomatic and maxillary reconstructions. Mandibular repair was carried out in 26 patients. Four patients had extensive soft tissue loss replaced with free vascularized omentum flaps. The omentum was used to provide contour and bulk together with concomitant coverage of the bone grafts and plates together with obliteration of the dead space. Their principles of reconstruction were as follows:—

(a) In the less severe injuries, immediate definitive bone and soft tissue repair was accomplished. This can be applied to the management of low velocity type injuries.

(b) In the more severe injuries with extensive bone and soft tissue loss, immediate debridement and temporary soft tissue repair covering exposed was done. Further debridement was employed when necessary.

(c) Within seven to ten days, delayed primary definitive reconstruction together with replacement of the missing midfacial bone and soft tissue was performed.

(d) Later repair involving scar revision, oral commissure creation, nasal reconstruction and bony mandibular reconstruction was carried out.

Therefore, early definitive midfacial bony and soft tissue treatment was performed. Mandibular defects were initially stabilized using long–span reconstruction plates with delayed bone grafting employed once a definitive intra–oral seal was obtained. Autogenous iliac cancellous bone grafting was their preferred choice in mandibular bony defects which measured up to 4cm in length. Larger mandibular defects were reconstructed using free vascularized bone grafts. Their overall success rate was satisfactory with one patient developing early infection requiring removal of the bone grafts. Three other bone grafts from different patients required removal at three to six months from resulting sepsis. One patient had failure of a free flap due to inadequate perfusion.

Vásconez *et al.* (1996) treated 33 patients with high velocity gunshot injuries to the face over a 18 year period between 1976 to 1993 at the University of Kentucky Chandler Medical Centre, USA. They divided their patients into two groups. Group I included 13 patients who underwent delayed definitive reconstruction procedures. Group II consisted of 20 patients who underwent primary reconstructive procedures. Their principles of reconstruction were similar to those described by Gruss *et al.* (1991). Their results showed that the patients in Group I had three times more surgical procedures than the patients in Group II. The complication rate (i.e. infections, contractures and non–union of fractures), were less in Group II.

Therefore, the argument for early definitive reconstruction in patients with large soft tissue and bony defects from resulting low and high velocity gunshot injuries provides promise for the future. It must be mentioned, however, that the above mentioned studies undertaken by Gruss *et al.* (1991) and Vásconez *et al.* (1996) had short term follow–up recall appointments usually up two years. Longer term follow–up studies are required to prove the efficacy of these treatment protocols.

The overall literature regarding the management of low velocity gunshot wounds to the maxillofacial region still seem to favour the conservative approach. Controversy regarding the definitive bony and soft tissue management of high velocity injuries still exist. Most reconstructive surgeons favour the involvement of a multidisciplinary team approach in the management of these complex injuries (Rowe and Williams, 1985).

In summary, the literature reviewed states that the wounding capacity of a missile is directly related to the energy transfered by the bullet to the surrounding tissue with the mass and velocity being important paramaters. Gunshot injuries seen during peacetime are caused by low velocity handguns. The overall prevalence of gunshot injuries appear to be increasing in large urban populations with males being affected more often than females. Generally, most entrance wounds were located within the midfacial region. Low velocity handgun injuries usually produce localized circumscribed small entrance wounds with comminution of bone and teeth with displaced fractures appearing to be more common. Associated bodily injuries that present with concomitant maxillofacial gunshot injuries depend on the path of the missile encountered. The initial management focused on airway control and ventilation followed by the arrest of any haemorrhage. Thereafter, special investigations consisting of standard plain film radiographs together with other complex investigations e.g. CT–scans (Computer Tomography scans), carotid angiograms were requested where indicated. Generally the management of low velocity gunshot wounds to the maxillofacial region still seem to favour the conservative approach with early local soft tissue debridement and closed reduction and fixation of comminuted fractures together with conservative removal of unpedicled bony fragments and extraction of teeth and root fragments. Bony and soft tissue defects were usually reconstructed secondarily as a delayed procedure. The post–operative complication rate reported by the literature reviewed were low. The most common reported complications were sepsis and bony and soft tissue residual defects.

3. RATIONALE, AIM AND OBJECTIVES

3.1 RATIONALE

The rationale for this study is to provide a better overall understanding of gunshot injuries and its resulting wounding effects on the maxillofacial region. In so doing, making our management protocols of these injuries more simple and effective. This would minimize the overall complication rate, number of operations and total hospitalization. The resulting outcome would make our treatment provided more cost effective. The overall success of the treatment provided will be assessed by evaluating the overall onset and types of complications and the overall rehabilitation of the patient to normality both cosmetically and functionally.

3.2 AIM

The aim of this study was to analyze the demographic data, patterns, management and complications of gunshot injuries to the maxillofacial region treated at Groote Schuur Hospital, Cape Town, from 1980 to 1995.

3.3 OBJECTIVES

3.3.1 To describe the sample by age, gender, income status and residential area.

3.3.2 To determine:—

(a) The prevalence of maxillofacial gunshot injuries by year;

(b) The velocity of the missiles used; i.e. high or low velocity bullets;

(c) The calibre of firearms used;

(d) The range at which the injuries occurred;

(e) Whether the injury was:—

(i) accidentally self–inflicted;

(ii) intentionally self–inflicted;

(iii) accidentally inflicted by another; or

(iv) intentionally inflicted by another.

(f) The site and pattern of hard and soft tissue injuries;

(g) The type of airway protection provided;

(h) The presence of any associated injuries;

(i) The different special investigations requested;

(j) The timing and type of treatment provided;

(k) The types of antibiotics used;

(l) The mean hospitalization stay; and

(m) The onset and types of complications present.

3.3.3 To suggest management recommendations.

4. MATERIALS AND METHODS

4.1 STUDY DESIGN

A record–based retrospective analyses of gunshot injuries to the maxillofacial region examined and treated at Groote Schuur Hospital over a fifteen year period (1980 to 1995) was carried out.

The necessary data were obtained from relevant treatment notes, radiographs and other special investigations undertaken and recorded in the hospital treatment notes.

4.2 STUDY POPULATION

The following inclusion and exclusion criteria for case selection were used:—

(a) Gunshot injuries pertained to the maxillofacial region were included;

(b) Patients who died as a result of the injury were excluded from the study; and

(c) Cases with incomplete, illegible handwriting or lost treatment notes were excluded.

The initial assessment of a patient is done by the surgical trauma registrar present at the Trauma Unit, Groote Schuur Hospital. The necessary data is recorded onto a trauma unit record and coded **(refer to Appendix I)**. The data is then recorded and stored into a computer data base for gunshot injuries seen at the trauma unit by the Department of Medical Informatics at Groote Schuur Hospital. For this study, the relevant hospital folders of patients with maxillofacial gunshot injuries was retrieved from this common data base **(refer to Appendix II)**. All the necessary information was recorded onto a proforma **(refer to Appendix III)**. The variables noted on the proforma were studied.

4.3 MEASUREMENTS

Most of the variables in the proforma are self explanatory except for the income status and the residential area.

4.3.1 Income status

Patients were categorised into different income categories based on their gross monthly income accrued. These were categorised into:—

H1 – earning up to R916.00 per month.

H2 – earning between R916.00 to R1,333.00 per month.

H3 – earning between R1,333.00 to R1,916.00 per month.

Private – earning above R1,916.00 per month.

These amounts were determined by the local Provincial Department of Health and categorized as indicated above.

4.3.2 Residential area

The various areas in which the patients resided at the time of injury were recorded. These were then categorised into "Black," "Coloured" and "White" residential areas[3] for the purposes of the study.

[3]Refer to footnote 1.

4.4 PILOT STUDY

A pilot study of 59 randomly selected cases of maxillofacial gunshot injuries were undertaken. These included cases treated at Groote Schuur Hospital over a five year period ranging from 1991 to 1995. The results of the pilot study were used to evaluate the methodology of the present study and to modify the proforma.

4.5 DATA CAPTURING AND ANALYSIS

The completed proformas were processed and the data was recorded onto the Quattro Pro IV computer package. The data was then subjected to statistical analysis using the EPI–INFO statistical computer package. Frequency distribution of all the variables were assessed as well as association between different variables (e.g. prevalence of maxillofacial gunshot injuries by year). The relevant data are represented graphically by means of pie charts or frequency bar graphs or in the form of frequency tables.

4.6 STAFF, FACILITIES AND EQUIPMENT

The facilities available at the University of the Western Cape, Oral Health Centre and World Health Organisation Collaboration Centre and the Department of Maxillofacial and Oral Surgery, Groote Schuur Hospital were utilized.

4.7 ETHICAL CONSIDERATIONS

Written permission for the use of hospital records were obtained from the Chief Medical Superintendent of Groote Schuur Hospital **(refer to Appendix IV)**. Written permission and acknowledgements for reproduced graphs, photographs and results were obtained. Strict confidentiality was adhered to. Only the patient's folder numbers were recorded onto the proforma. Clinical photographs were taken with the patient's permission.

5. RESULTS

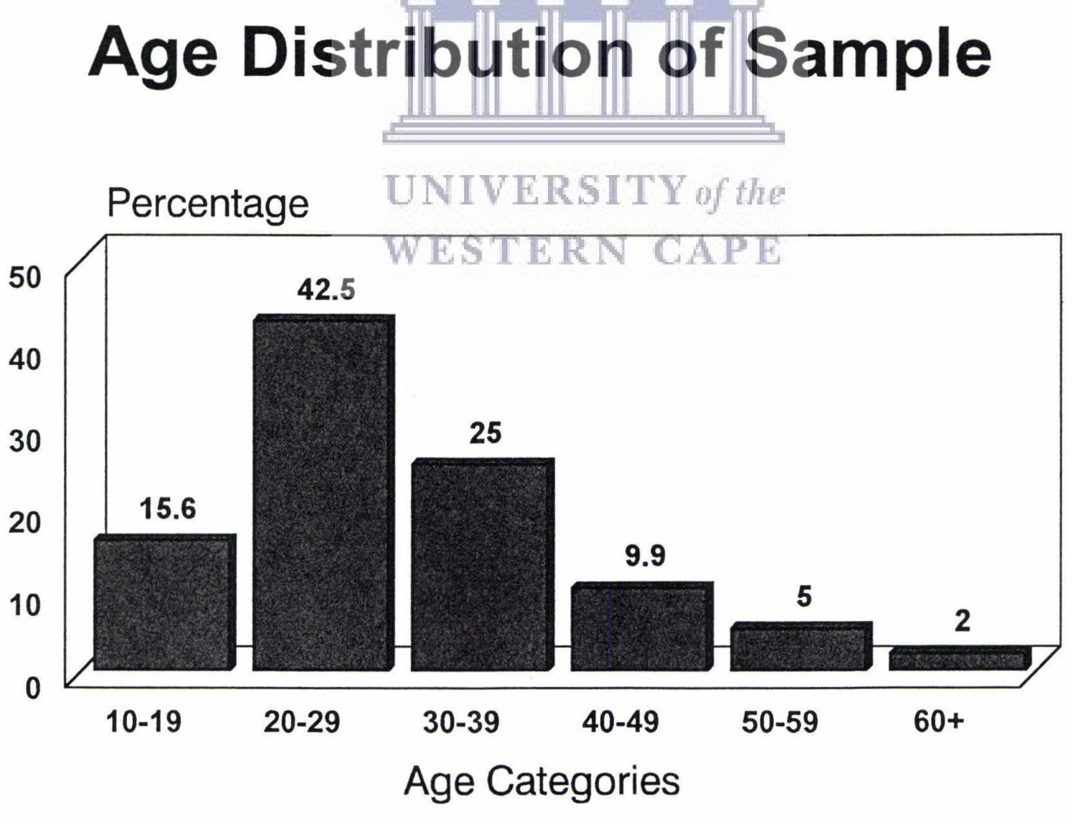
5.1 SAMPLE SIZE

There was a total of 360 maxillofacial gunshot injury patients who presented to Groote Schuur Hospital from 1980 to 1995. After application of the inclusion and exclusion criteria, a total of 301 cases were analyzed.

5.2 DEMOGRAPHIC CHARACTERISTICS OF THE SAMPLE

5.2.1 Age distribution

The age of the sample ranged from 12 to 85 years with a mean age of 30 years. Patients within the third decade of life were most frequently affected. For the age distribution within decades **refer to GRAPH 2 below.**



5.2.2 Gender

Males (86%) were overwhelmingly more commonly affected than females (14%).

5.2.3 Income status

The majority of the cases (96.6%) were of a lower socio–economic status (category H1– earning up to R916.00 per month).

5.2.4 Residential area (refer to Appendix V)

The majority (77%) of the sample population resided in the traditionally "Black" and "Coloured" residential areas.

Most victims resided in the "Black" areas, comprising 44% of the sample. Most of these patients (42%) resided in Khayelitsha.

The patients who resided in the "Coloured" residential areas comprised 33% of the sample with the Athlone area (68%) being most commonly affected.

The rest of the sample (23%) resided in other residential areas.

5.3 VELOCITY OF THE MISSILE

The majority (85%) of the injuries were due to low velocity handguns. The balance (15%) were due to intermediate velocity shotgun injuries. There were no high velocity type injuries recorded.

5.4 CALIBRE OF WEAPON USED

In 95% of the sample, it was difficult to accurately assess the exact calibre of the weapon used. The patients, their family, witnesses, paramedics or police officers could not report this information.

5.5 RANGE AT WHICH INJURIES OCCURRED (TABLE 1)

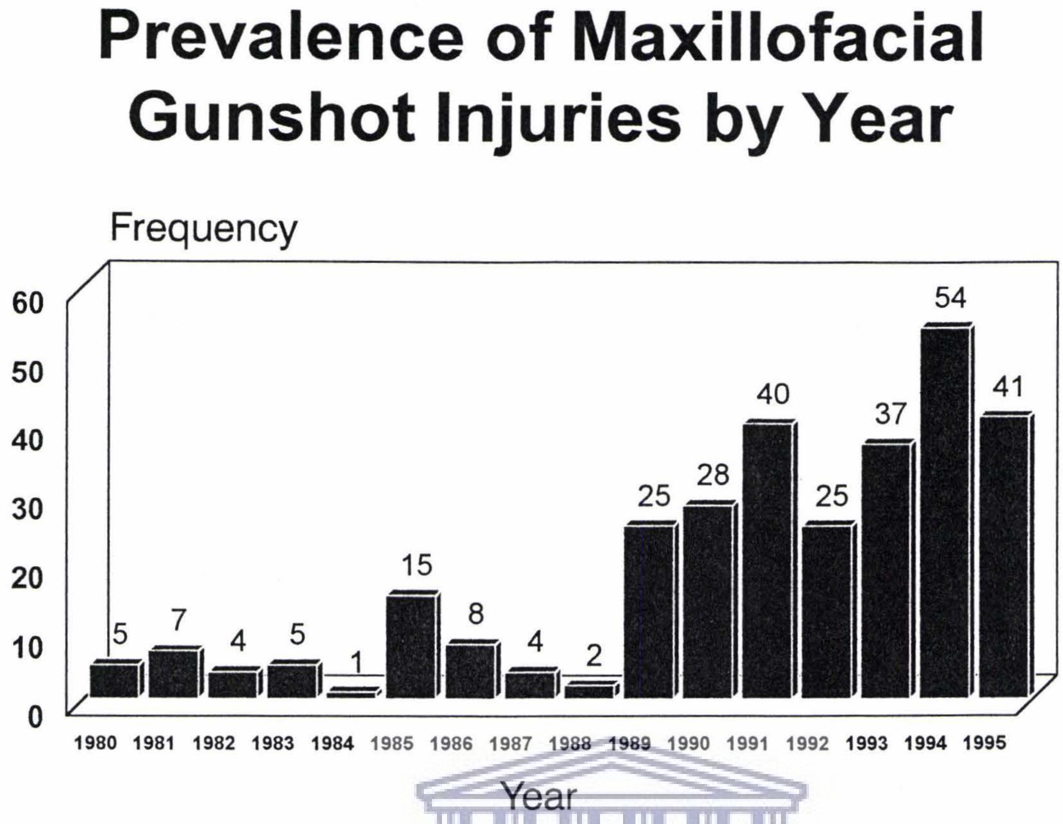
RANGE	NUMBER OF PATIENTS	PERCENTAGE
Close	121	40
Far	18	6
Unknown	162	54

In approximately half of the sample the range at which the missile was fired from was unknown. Of the remaining cases, the closer range injuries were more common.

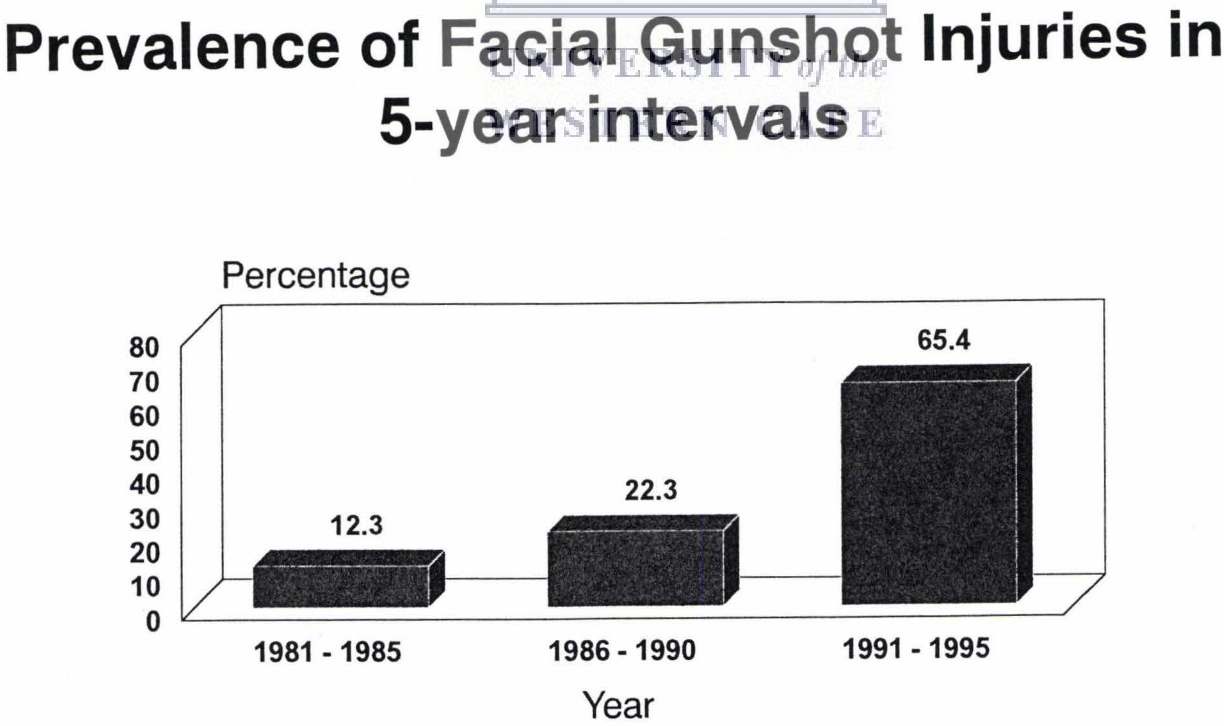
5.6 PREVALENCE OF GUNSHOT INJURIES

It is evident from the graphs below that maxillofacial gunshot injuries are increasing exponentially over the years. Most of the gunshots (65%) were seen post 1990 (refer to graphs 3a and 3b).

Prevalence of Gunshot Injuries by Year (Graph 3a)

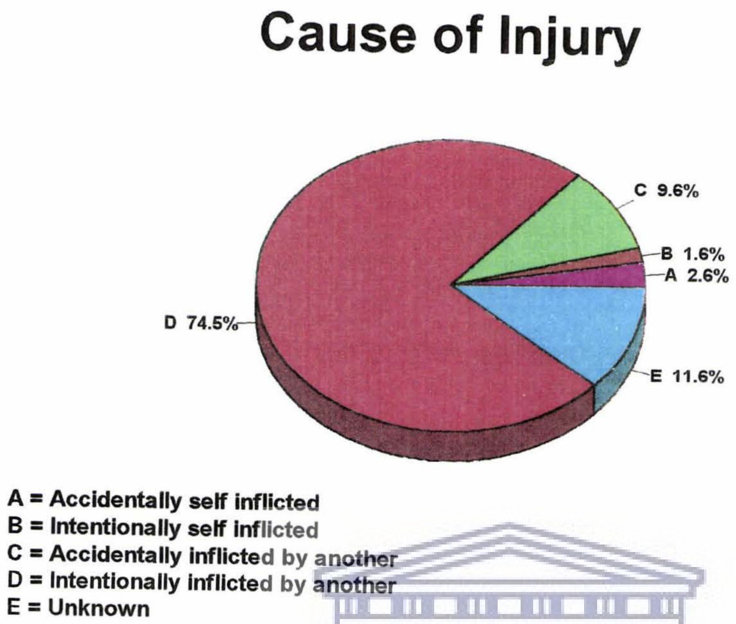


Prevalence of Gunshot Injuries by 5-year intervals (Graph 3b)



5.7 CAUSE OF INJURY (GRAPH 4)

In the majority of the sample (75%), the gunshot injuries were intentionally inflicted by others. In 12% of the sample, the purpose and mechanism of the injuries were unknown.



5.8 SOFT TISSUE INJURIES

All the patients had soft tissue injuries with small circumscribed entrance wounds measuring approximately 5x5mm in size. The surrounding wound edges were often ragged and necrotic. The wound tract often contained necrotic debris, tooth and bone fragments. There was usually surrounding ecchymosis, oedema associated with the wounds. Two patients had close range shotgun injuries with large avulsive entrance wounds. In 10% of the patients with closer range low velocity injuries surrounding gunpowder burns were evident around the entrance wound. In 90% of the shotgun injuries, the entrance wounds were small and widely dispersed usually measuring 1x1mm in size. Of the suicide cases (2%), the entrance wounds were slightly larger measuring 15x15mm. Majority of the patients (63%) had no exit wounds. The exit wounds were generally slightly larger in size than the entrance wounds. These were usually ragged or stellate type wounds with necrotic edges. Four patients with intermediate velocity type injuries had large avulsive exit wounds.

5.8.1 Site of entrance wound (TABLE 2)

ANATOMICAL SITE	PERCENTAGE
Cheek	27
Mouth area	16
Chin area	8
Eye area	16
Ear area	15
Combination of above sites	19

The cheek was the most common site of entrance wound followed by a combination of various sites.

5.8.2 Site of exit wound

In the majority of the sample (63%) there were no exit wounds. In those with an exit wound, the cheek (43%) was the most common exit site recorded.

5.9 HARD TISSUE INJURIES (TABLE 3)

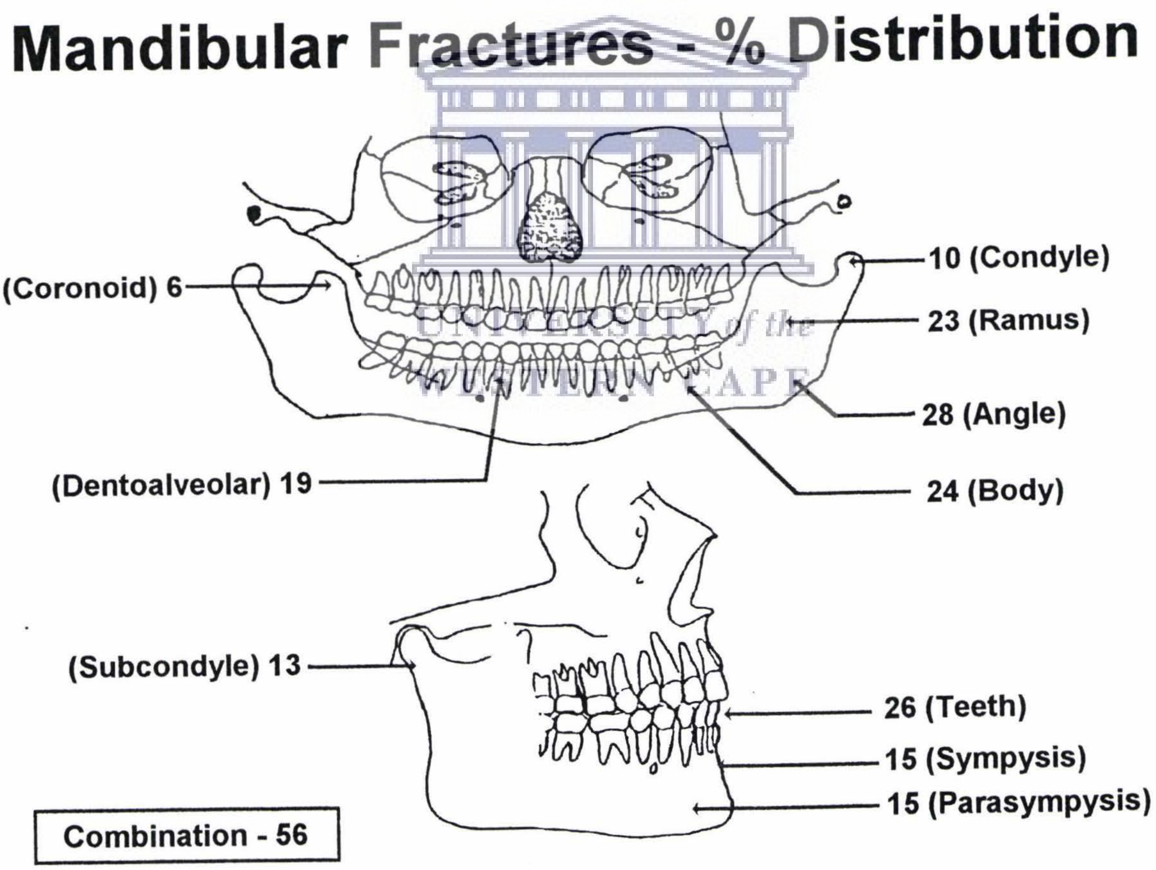
TYPE OF FRACTURE	NUMBER OF PATIENTS (n = 197)	PERCENTAGE
Simple Undisplaced	37	19
Simple Displaced	13	7
Comminuted Undisplaced	27	14
Comminuted Displaced	73	37
Teeth Fractures	7	4
Combination of above Fractures	40	20

A total of 197 (65%) patients had hard tissue injuries (i.e. bone fractures and/or teeth fractures). The rest of the patients had isolated soft tissue injuries. The comminuted displaced type of fracture (37%) was most common.

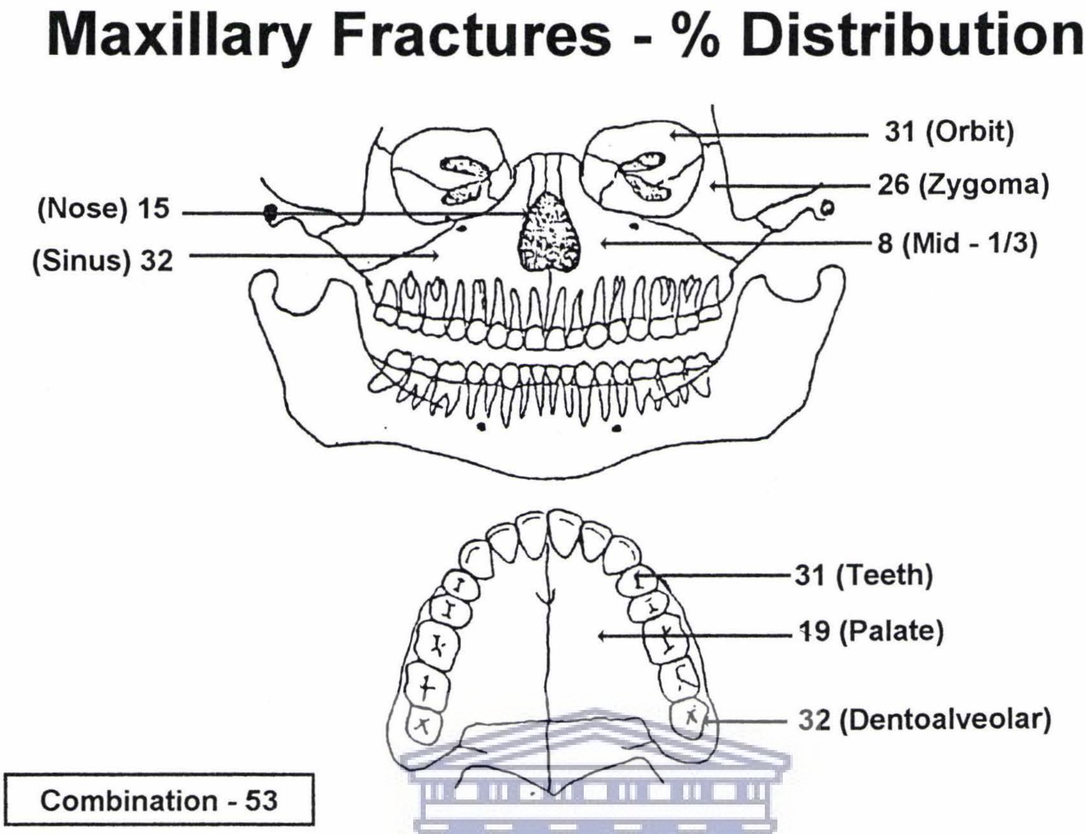
5.10 MANDIBULAR AND MAXILLARY FRACTURES

The mandibular fractures were more common than the maxillary ones. There were 102 (34%) mandibular and 88 (29%) maxillary fractures.

5.10.1 Distribution of mandibular fractures (DIAGRAM 4)



5.10.2 Distribution of maxillary fractures (DIAGRAM 5)



5.11. COMPARISON OF MANDIBULAR AND MAXILLARY FRACTURES (TABLE 4)

TYPE OF FRACTURE	PERCENTAGE OF MANDIBULAR (n = 102)	PERCENTAGE OF MAXILLARY (n = 88)
Simple Undisplaced	18	10
Simple Displaced	3	5
Comminuted Undisplaced	20	16
Comminuted Displaced	61	69

In both the mandibular and maxillary fractures, the comminuted displaced fracture was the most common type of fracture noted.

5.12 AIRWAY MANAGEMENT

The majority of the patients (86%), required no airway management. Of the patients with airway compromise:—

(a) Oral or nasal endotracheal intubations were performed in 43% of the patients.

(b) Initial endotracheal intubations with later elective tracheostomies were performed in 2% of the sample.

(c) Emergency cricothyroidotomies were done in 5% of cases.

(d) Tracheostomies were performed as an isolated procedure in 33% of the patients.

(e) One patient had an emergency cricothyroidotomy done initially and was later converted to an elective tracheostomy.

5.13 ASSOCIATED INJURIES (TABLE 5)

ANATOMICAL SITE	PERCENTAGE NUMBER OF PATIENTS (n = 120)
Head	27
Neck	18
Thorax	3
Abdomen	5
Limbs	21
Combination of Sites	27

The majority of the sample (60%) had no associated bodily injuries. The most common associated injuries are the head, limb and neck injuries. The thorax and abdomen were the least common associated injuries recorded.

5.14 SPECIAL INVESTIGATIONS

No special investigations were required in 9% of the sample. Conventional plain film X–rays alone were requested in 59% of the cases. A combination of conventional plain film X–rays, angiograms and computer tomography (CT) scans of the head were requested in 41% of the sample. Angiograms of the carotid arteries were done in 76% of patients with associated neck injuries. CT–scans of the head were requested in 81% of patients with associated head injuries.

5.15 SURGICAL TREATMENT

5.15.1 Soft tissue management

Early soft tissue debridement was performed within 12 to 24 hours of presentation in 85% of the patient sample. With close range injuries, more avulsive type entrance and exit wounds were present. Local soft tissue flaps were required to close tissue defects in 16% of the total sample. Distant soft tissue flaps were harvested in two patients with large avulsive wounds.

5.15.2 Hard tissue management (comprising of those with fractures, n = 197)

(i) Hard tissue debridement

The majority of the patients (64%) had no hard tissue debridement done. Early hard tissue debridement (i.e. within 24 hours) was carried out in 23% of those patients who had a debridement performed.

5.15.3 Fracture management

(i) Timing of fracture management (TABLE 6)

TIMING	NUMBER OF PATIENTS	PERCENTAGE
Immediate (to 12 hrs)	55	29
Delayed (later than 12 hrs)	48	25
None	198	66

The majority of the patients (66%) required no fracture management. There is no significant difference in the timing of the fracture management of the patient sample.

(ii) Type of reduction (TABLE 7)

TYPE OF REDUCTION	Percentage of Mandibular Fractures (n = 102)	Percentage Of Maxillary Fractures (n = 88)
Open	35	23
Closed	26	8
None	39	69

In the mandibular fractures there were more open reductions (35%) than closed reductions (26%). In the maxillary fractures open reductions (23%) were performed more commonly than closed reductions (8%).

(iii) Type of fixation (TABLE 8)

TYPE OF FIXATION	Percentage of Mandibular Fractures (n = 102)	Percentage Of Maxillary Fractures (n = 88)
Plating	7	6
Wiring	36	11
Combination of Plating and Wiring	14	8
External Fixation	0	0
Grafting	4	3
None	39	69

In the mandibular fractures (12%) of the patients had a combination of open reductions with intermaxillary fixation. Amongst the maxillary fractures, (8%) of the patients had a combination of open reductions with intermaxillary fixation. Open reductions were performed in a total of 32 (17%) cases. Closed reductions were performed in a total of 27 (15%) cases. In all cases the closed reductions comprised of intermaxillary fixation alone. Amongst the mandibular fractures (39%) were treated conservatively and (69%) of the maxillary fractures were treated conservatively. Open reductions with rigid fixation comprising of plating were employed in (7%) of the mandibular fractures and (2%) of the maxillary fractures. Wiring alone (i.e. in both closed and open reductions) were more common in both mandibular (36%) and maxillary fractures (11%). A combination of plating and wiring was employed in (16%) of mandibular fractures and (8%) of maxillary fractures. No external fixations were used. Bone grafting was employed in (4%) of mandibular fractures and (3%) of maxillary fractures. Autogenous bone grafting was used in (95%) of both mandibular and maxillary fractures.

5.16 ANTIBIOTIC TREATMENT

The majority of the patients (73%) received antibiotic treatment. Penicillin was the most commonly used antibiotic. A combination of penicillin and metronidazole was used in 43% of patients. The patients who received antibiotics for longer than one week comprised of 31% of the patients. Patients with isolated soft tissue injuries received a stat dose of intramuscular penicillin in (18%) of the cases. All the patients received an anti–tetanus toxoid injection on admission.

5.17 HOSPITALIZATION (TABLE 9)

NUMBER OF DAYS	NUMBER OF PATIENTS
0	69
1 — 10	204
11 — 20	22
21 — 30	6

A total of 232 patients were hospitalized for longer than one day. A mean hospitalization stay was six days for these patients.

5.18 COMPLICATIONS

5.18.1 Onset of complications

The overall complication rate was 60% with the early presenting complications (86%) being more common than the later presenting ones (15%).

5.18.2 Types of complications (TABLE 10)

TYPES OF COMPLICATIONS	NUMBER OF PATIENTS (%)
Sepsis	19
Limitation of mouth opening	46
Blindness	26
Neurological	48
Other	67
Combination	37

Of the patients with complications:—

(a) Post–operative sepsis was recorded in 19% of the sample. Osteomyelitis of the mandible was reported in 19% of the sample.

(b) Limitation of mouth opening occurred in 46% of the sample. Zygomatico–coronoid ankylosis was reported in two cases.

(c) Blindness was a complication in 26% of the sample.

(d) (i) Neurological complications occurred in 48% of the sample.

(i) Neurological Complications (TABLE 11)

NERVE INVOLVEMENT	PERCENTAGE (n = 86)
Oculomotor Nerve	2
Trigeminal Nerve — Infraorbital	4
— Inferior alveolar	12
Facial Nerve	26
Glossopharyngeal Nerve	2

(ii) Facial nerve injury was the most common recorded neurological complication comprising of 26% of the total neurological complications.

(e) (i) Of the *other* complications, the ocular complications were most common.

(ii) Ocular Complications (TABLE 12)

OCULAR COMPLICATIONS	PERCENTAGE (n = 51)
Hyphaema	43
Retinal Detachment	2
Vitreous Haemorrhage	24
Scleral Laceration	16
Corneal Laceration	14
Horner's Syndrome	2

Hyphaema (43%) was the most common ocular complication recorded. Of the remaining *other* complications:—

(ii) Oro–antral communications were recorded in 6% of the sample.

(iii) Oro–nasal fistulae were recorded in 3% of the sample.

(iv) Parotid fistulae were recorded in 2% of the cases.

(v) Pharyngeal injuries were recorded in 5% of the cases.

(f) A combination of complications occurred in 37% of the total recorded complications.

6. DISCUSSION

6.1 AGE, GENDER AND INCOME STATUS OF SAMPLE

This report indicates that males within their third decade of life were most often the victims of gunshot injuries. A vast majority of patients earned less than R1000.00 per month or were unemployed and resided in the lower socio–economic areas in Cape Town.

These findings are consistent with other local and international gunshot related studies undertaken (Veller and Green, 1984; Fleming *et al.*, 1993; Tsakiris *et al.*, 1996; Yao *et al.*, 1972; May *et al.*, 1973; Shuck *et al.*, 1980; Banks, 1985; Gussack and Jurkovich, 1988; Nelson *et al.*, 1987; Haug, 1989; Neupert *et al.*, 1991; Fonseca and Walker, 1991; Dolin *et al.*, 1992; Kihtir *et al.*, 1993; Laskin, 1994). Firearm related mortality statistics indicate that males within their twenties were commonly affected (Veller and Green, 1984; Lerer *et al.*, 1997). Lerer *et al.* (1997) reported that the lower socio–economic residential areas in Cape Town: Khayelitsha, Guguletu, Mitchells Plain, Nyanga and Bishop Lavis were regarded as the five top homicide areas respectively.

In South Africa, various socio–political circumstances enforced by a previous Nationalist apartheid government including the Group Areas Act of 1950 has resulted in various deleterious effects upon the economic and social situation of the majority of our population. The majority of the previously disenfranchised population are either unemployed or earn a low wage and live in poorly maintained and serviced residential areas. This has resulted in a drastic increase in the crime rate and firearm related violence. With the increasing crime rate, many more people possess firearms for personal protection. A firearm in the house has also been shown to increase the risk of suicide and homicide (Laskin, 1994; Lerer *et al.*, 1997). American studies have indicated that in 1990, 82% of homicides in teenagers 15 to 19 years were associated with firearms. The possession of a handgun may thus pose more of a danger than a panacea.

6.2 VELOCITY AND CALIBRE OF WEAPON USED

Firearm injuries encountered by the traumatologist in peacetime are produced mostly by low calibre, low velocity handguns (Haug, 1989). The steadily increasing level of urban violence and attempted suicides has resulted in a large number of gunshot injuries to the face from small calibre weapons (Williams *et al.*, 1988). These findings are consistent with those reported in this study. A smaller percentage of the injuries were due to intermediate velocity shotguÿ missiles. These were mainly as a result of the usage of shotguns by the riot police during confrontation with the civilians, mostly young adults during political uprisings in the mid to latter 1980's. In the majority of cases, the exact calibre of the weapon could not be determined since most were intentional assault cases where the assailant often disappeared from the scene of the crime.

On inspection of the entrance and exit wounds, as well as interpretation of the radiographs, the attending surgeon can often distinguish between lower velocity type injuries from higher type injuries. This, however, may be complicated with very close range low velocity gunshot injuries with the wounding effect being similar to higher velocity type injuries. These cases were often attempted suicide incidents where the velocity and calibre of the weapon was known.

In approximately 25% of the low velocity handgun injuries, the exact calibre of the weapon was known. These ranged from 0.22 to 0.45 calibre type weapons. The 0.357 magnum, 9mm and 0.38 special type handguns were most commonly used in these cases.

Shotguns were commonly used by law–enforcement officers during riots since these firearms cause a rapid dispersion of pellets with a resultant increase in the probability of reaching their targets (Swan and Swan, 1991). "Plastic bullets" were also used as anti–riot missiles e.g. in Northern Ireland (Banks, 1985). These cause a typical round bruising on the skin as evident from the present study. The shotgun injuries were easily determinable from the clinical picture of widely dispersed small rounded entrance wounds which were noticeable on the radiographs together with no exit wounds.

It is generally accepted that in gunshot injuries, the calibre and mass of the missile are important determining factors with regards to the extent of the bony and soft injuries incurred. The velocity of the bullet is the most important parameter of the overall wounding capacity. From the previous discussion on wound ballistics, it is evident that the energy imparted from a missile to its target is related to the mass and velocity of the projectile as expressed by the formula:—

$$K = \frac{MV^2}{2}$$

Since the velocity is squared in the formula, it represents the greatest contribution to the energy transferred (Gant and Epstein, 1979). When a missile does not exit, then it imparts all its energy within its target tissue. If a missile exits, the energy transferred is expressed by the formula:—

$$K = \frac{M(V_1 - V_2)^2}{2}$$

Where V_1 is the impact velocity and V_2 is the exiting velocity (Holt and Kostohryz, 1983). May *et al.* (1973) have suggested that low velocity injuries are not related to missile calibre's alone, but are rather dependant upon the pathway of the missile. It is evident from the literature regarding wound ballistics, that there are many other factors, besides the velocity, mass and calibre of a projectile that determine the extent of an injury.

6.3 RANGE AT WHICH INJURIES OCCURRED

The wounding capacity of a missile is also determined by the distance of the target. At distances beyond ± 800 meters, the impact velocity and the resultant wounding capacity is reduced (Haug, 1989; Fonseca and Walker, 1991). In the present study, the range was unknown in 54% of the sample. This was probably due to the fact that the majority of the sample was due to intentional assault where the victims were unaware of the impending injury and were unable to report the range. This could also be due to the trauma officer not reporting this information. The injuries were regarded as close range when the weapon was fired at a distance of up to 10 meters. The further range injuries included those where the victim was further than 10 meters from the assailant. May *et al.* (1973) reported that in their study, the majority of the patients were shot at close range i.e. within 20 feet. This finding is consistent with the present study. Inspection of the entrance and exit wounds often indicates the approximate range at which injuries occur. Bullets fired at close range may cause significant powder burns and other epidermal injuries (Gussack and Jurkovich, 1988). Yao *et al.* (1972) reported considerable differences between the soft tissue damage inflicted by small calibre bullet and shotgun wounds. When considering shotgun wounds, the range becomes an important factor (Rowe and Williams, 1985; Williams *et al.*, 1988). Yao *et al.* (1972) reported on a classification of shotgun wounds into three types according to the range:—

[1] **TYPE I injuries —** long range over 7 yards. These usually penetrated subcutaneous tissue and the deep fascia.

[2] **TYPE II injuries —** closer range (3 to 7 yards). These usually penetrated body cavities.

[3] **TYPE III injuries —** point blank range (less than 3 yards). These usually caused extensive tissue damage.

In this study, most shotgun injuries occurred over a long range and occasionally cause vital organ damage when the pellets entered e.g. the eye. This classification could also apply to low velocity type wounds. At closer range, burns of the cutaneous surface or tattooing of the dermal layer by the projectile shavings or powder residue will occur. Here the exit wound will be stellate or slit–like (Haug, 1989).

In attempted suicide, the weapon is usually placed in contact with the skin and the muzzle velocity, then equals the impact velocity of the bullet. In this situation, pure "wound ballistics" related to velocity and mass of the projectile alone, excluding factors such as range apply.

6.4 PREVALENCE OF GUNSHOT INJURIES BY YEAR

Local and international studies reviewed have indicated an overall increase in the prevalence of gunshot injuries amongst the urban population (Yao *et al.*, 1972; Shuck *et al.*, 1980; Cohen, 1984; Veller and Green, 1984; Banks, 1985; Nelson *et al.*, 1987; Williams *et al.*, 1988; Haug, 1989; Laskin, 1994; Lerer *et al.*, 1997).

Nelson *et al.* (1987) in their study, reported the United States as having the highest incidence of firearm–related deaths among the western industrialized nations. This has resulted in a staggering financial burden on the overall health economy. The authors have quoted that "the firearm is so ingrained in the American experience that one must conclude gunshot injuries and fatalities are simply part of the cost of living in America today."

The local South African experience appears to be similar. Veller and Green (1984), reviewed gunshot injuries seen at the Johannesburg Hospital during 1982. They have concluded that the incidence of gunshot injuries have increased over the years and has placed a significant burden upon our local health care system. These findings were reinforced by a study done by Lerer *et al.* (1997) at the Medical Research Council regarding mortality of firearm related injuries in the Cape Town metropolitan area during 1994 and 1995. It appears that the use of handguns amongst civilians has become more common, not only for suicidal purposes but also as a weapon of assault.

Together with these harsh mortality statistics related to firearm related injuries, the steady increase in the level of urban violence has resulted in an increase in the prevalence of maxillofacial gunshot injuries seen locally and internationally (Yao *et al.*, 1972; Cohen, 1984; Rowe and Williams, 1985; Williams *et al.*, 1988; Haug, 1989; Fleming *et al.*, 1993; Kihtir *et al.*, 1993; Laskin, 1994; Tsakiris *et al.*, 1996).

The findings of the present study are similar to those reported above with most of the gunshots seen post–1990. The highest incidence of maxillofacial gunshot injuries were seen in 1994, the year of our country's first democratic national elections. Most of the shotgun injuries were seen during the mid and latter 1980's during which most of the political uprisings and riots had taken place.

6.5 CAUSE OF INJURY

Violence and crime are dominant themes in any discussion on South Africa and its future (Lerer, 1997). The local media has reported a drastic increase in the local crime rate in South Africa with the Western Cape being the most violent and crime–ridden province after Gauteng. The firearm related deaths in Cape Town have increased from below 200 in 1991 to 600 and above in 1995 (Lerer *et al.*, 1997).

Veller and Green (1984) in their study on gunshot injuries seen at the Johannesburg Hospital during 1982 reported that the majority of cases reviewed were due to assault followed by accidental gunshot injuries and suicide attempts. The findings in the present study are similar with the vast majority being due to intentional assault. The accidental injuries which were either self–inflicted or inflicted by another were below 10% of the total sample. These accidental injuries frequently occurred while "unloaded" firearms were being cleaned.

A recent survey on facial trauma undertaken at the Department of Maxillofacial and Oral Surgery at Groote Schuur Hospital (Lalloo, 1997) indicated that interpersonal violence is the most common cause resulting in facial fractures. These findings were similar to those studied by Lownie and Lownie (1996) in their presentation of facial fracture trends seen at the teaching hospitals in Gauteng over a fourteen year period up to 1995. They also noted that the increase in gunshot injuries accounted for second commonest cause of facial fractures. In the Western Cape, the interpersonal violence can be accounted for by the mixture of "intergenerational poverty, a growing gap between the ultra–poor and the economically privileged" with the pre–existent apartheid repression amongst the underprivileged communities (Lerer, 1997). This is further complicated by the increase in gang and taxi warfare in the Western Cape.

Pinnock (1984) carried out an extensive research of the street gangs in the Cape Flats. He refers to the "Cape Flats" as being a lower socio–economic area where the "Coloured and African" working class have been relocated by massive population removals from the inner city area during the apartheid era. It is in these areas where most gangs reside. Territorial struggles have often caused gang warfare and resultant "shooting wars and constant skirmishes." He also quotes that the gangsters "are generally armed, often with sophisticated stolen weaponry". The Safety and Security Minister, Sidney Mufamadi, reported that 19600 South Africans with criminal records are registered firearm owners and 1901 people who were declared unfit to possess firearms, are currently in possession of licensed firearms (The Natal Witness Newspaper, 1997).

Accompanying the interpersonal violence in South Africa, other factors including economic interests, such as those associated with the battle for control of lucrative taxi routes have resulted in increased homicidal firearm use. The workload of the law enforcement authorities have been increased by the upsurge of local civilian vigilante groups with an increase in the ownership of firearms for protection purposes (Lerer, 1997). Studies have shown that firearms are likely to kill or injure someone in the owner's own household. The presence of a firearm in household increases the risk of suicide and homicide (Laskin, 1994; Lerer *et al.*, 1997).

One can also assume that it is people, not guns, that kill. Other factors such as poverty, substance abuse, alcoholism and violence in the media are coincident factors in firearm related injuries and fatalities.

American studies have shown that suicide is the second most common cause of death among "white" males aged between 15 to 19 years with firearms accounting for up to 47% of all suicides. Self inflicted gunshot wound to the face are, however, relatively uncommon (Shuck *et al.*, 1980). Lerer *et al.* (1997) have cited that firearms are the main method of suicide amongst whites contributing to 30% of all suicides occurring commonly within the third decade of life. The present study has shown that self-inflicted facial gunshot injuries are relatively uncommon accounting for less than two percent of the sample.

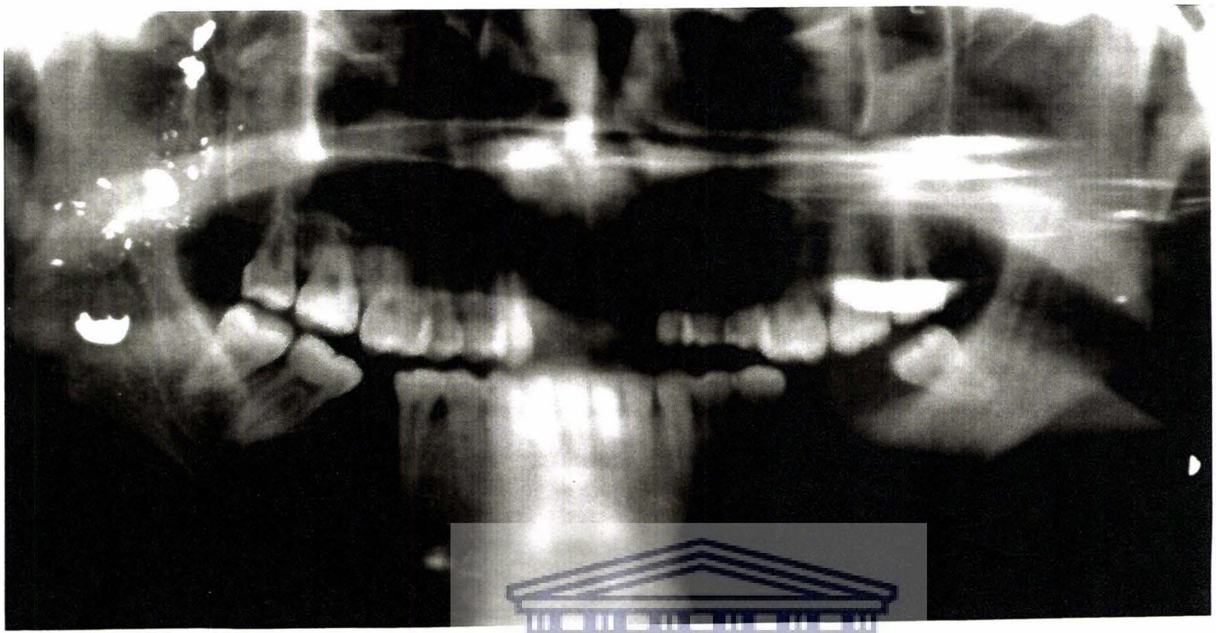
In approximately 11% of the sample in the present study, the cause of the firearm injury was unknown. This was probably due to the fact that the necessary information was not recorded or that the law enforcement officers, witnesses or victims were unable to volunteer this information.

6.6 SOFT AND HARD TISSUE INJURIES

In the present series, it is significant that in 65% of the cases, there were combined soft and hard tissue injuries. The rest were confined to the soft tissue alone. These findings were similar to those reported by Gant and Epstein (1979) where 20 of the 66 cases of low velocity injuries to the maxillofacial complex involved the soft tissue alone, without the presence of fractures. These findings represent nearly one–third of the cases and appears relatively high when one considers the anatomy of the face. The intricate relationship of the soft tissue to the bony skeleton suggests that the soft tissue injury without that of the hard tissue appears to be unlikely. This reinforces the idea that the pathway of missile wounds in the maxillofacial appears to be unpredictable (Haug, 1989). The present study also indicates that in the majority of cases, there were no exit wound. This finding was consistent with those reported previously (Yao *et al.*, 1972; May *et al.*, 1973; Gant and Epstein, 1979; Zide and Epker, 1979; Cohen, 1984; Haug, 1989; Neupert III *et al.*, 1991).

Generally, low velocity entrance wounds are often predictable in their presentation (Cohen, 1984). The present study shows most low velocity entrance wounds as being small circumscribed areas often with underlying comminution of bone and no exit wounds. In contrast, closer range shotgun wounds and higher velocity handgun injuries e.g. magnum handguns produced large avulsive gaping wounds. The "plastic bullet" which is used for anti–riot purposes, e.g. in Northern Ireland, causes a typical round bruise on the skin (Rowe and Williams, 1985). These type of wounds were seen in a few cases in the present study especially during the mid 1980's during the political riots. The pathway of the bullet may often be traced by projecting a line between the entrance and exit wounds (May *et al.*, 1973). In many cases, however, the bullet is deflected off bony structures at a tangent and an irregular pathway is present. More reliably, the pathway of the bullet may be seen radiologically by the presence of lead fragments along the bullet tract (Cohen, 1984).

Fig. 1 Orthopantomogram showing presence of lead fragments along a bullet tract



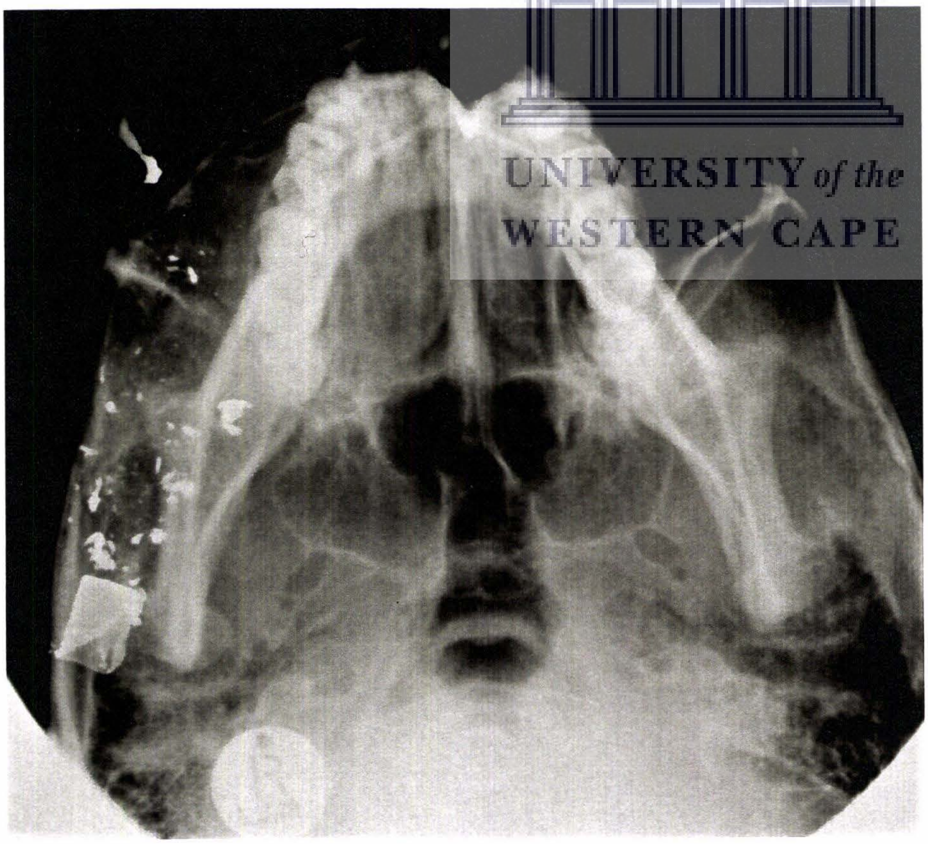


Fig. 2 Submentovertex view showing a bullet jacket with lead fragments along a bullet tract

Fig. 3 Small circumscribed entrance wound

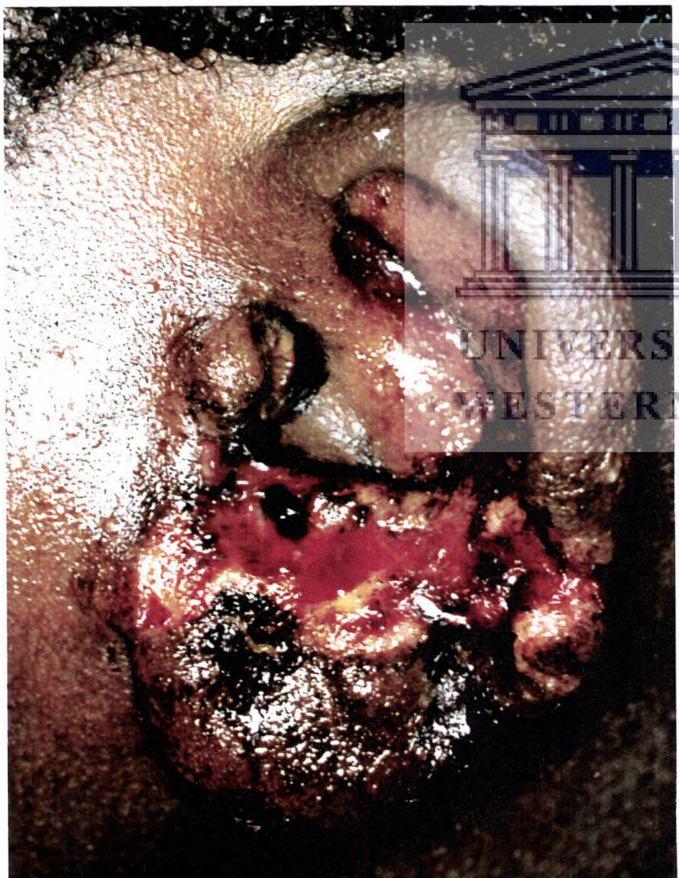


Fig. 4 Isolated soft tissue injury to the ear

Fig. 5 Small circumscribed exit wound

Fig. 6 Large avulsive exit wound caused by magnum handgun

Fig. 7 Stellate type exit wound

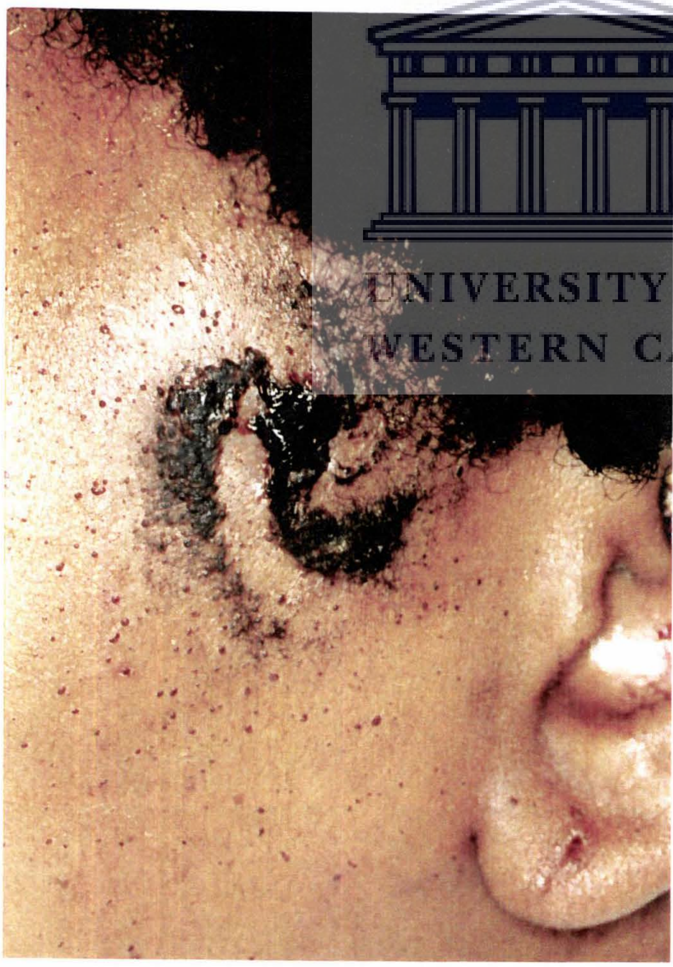


Fig. 8 Entrance wound with surrounding powder burns

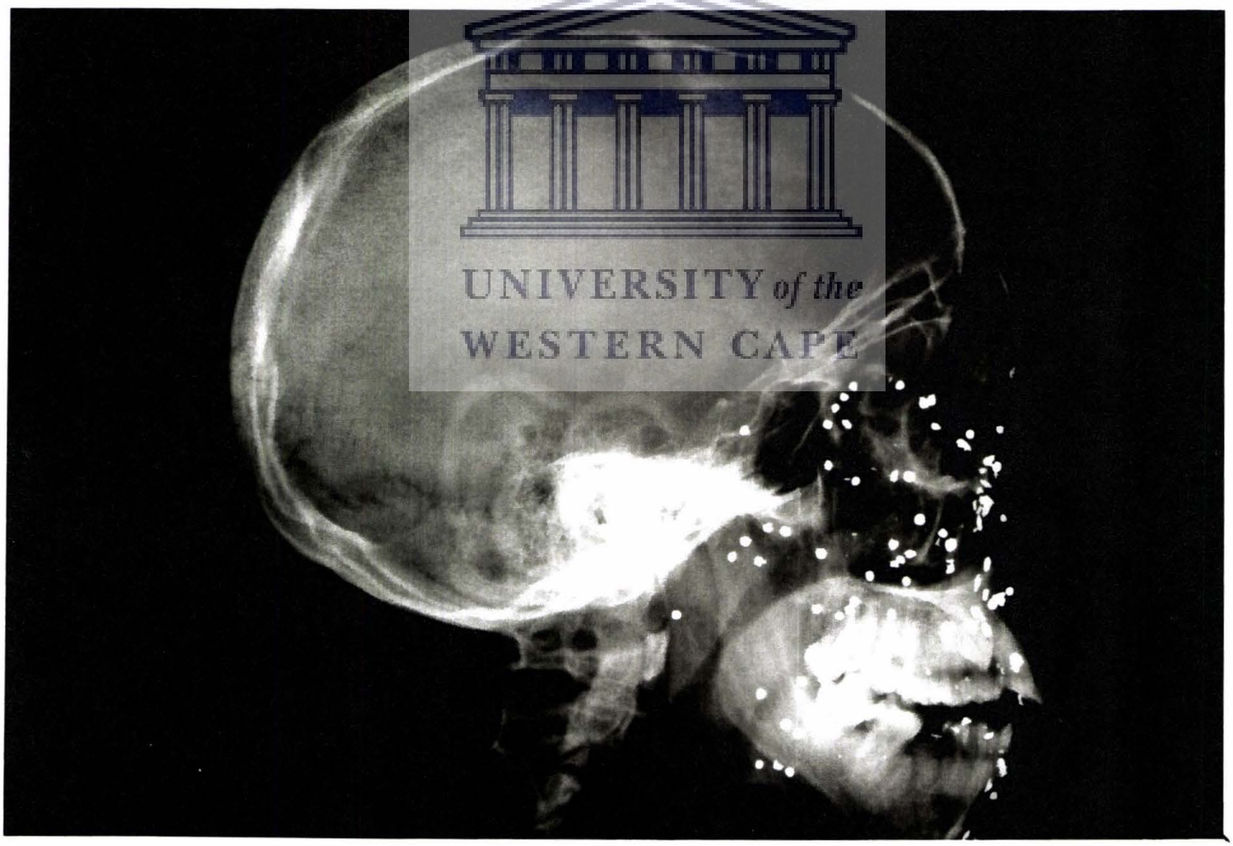
6.7 SHOTGUN INJURIES

In the present series studied, the majority of the shotgun injuries were fired from distant ranges. This is evident from the resulting wounding pattern with wide dispersion of the shotgun pellets throughout the head and neck region. These injuries usually had no exit wounds and rarely caused significant injuries unless the pellets had struck a vital organ e.g. the eye. This is in keeping with other international studies (Zide and Epker, 1971; Rowe and Williams, 1985; Fonseca and Walker, 1991) regarding shotgun injuries undertaken.

6.7 SHOTGUN INJURIES

In the present series studied, the majority of the shotgun injuries were fired from distant ranges. This is evident from the resulting wounding pattern with wide dispersion of the shotgun pellets throughout the head and neck region. These injuries usually had no exit wounds and rarely caused significant injuries unless the pellets had struck a vital organ e.g. the eye. This is in keeping with other international studies (Zide and Epker, 1971; Rowe and Williams, 1985; Fonseca and Walker, 1991) regarding shotgun injuries undertaken.

Fig. 9 Lateral skull view showing dispersion of shotgun pellets



In the present study, the cheek area was the most common entrance and exit site. This finding is in keeping with other local and international studies undertaken (Cohen, 1984; Fleming, 1993; Gant and Epstein, 1979; Gussack and Jurkovich, 1988; Kihtir *et al.*, 1993). One must also consider that the present study concurs with that of Kihtir *et al.* (1993) in that all intra– cranial injuries were excluded. This finding could also explain why the majority of the patients in the present study did not have any airway compromise. Airway management was required where the entrance and exit wounds occurred in the lower facial region.

6.8 TYPE OF FRACTURES

For the purposes of the present study, the hard tissue injuries have been classified into:—

[1] (a) Simple Displaced Fractures

(b) Simple Undisplaced Fractures

[2] (a) Comminuted Displaced Fractures

(b) Comminuted Undisplaced Fractures

[3] Teeth Fractures

This classification has been used since both the displaced and undisplaced fractures have different management protocols. The findings of the present study has shown that the comminuted displaced type of fracture was significantly more common than the rest of the fractures. May *et al.* (1973) in their study of twenty mandibular fractures resultant from gunshot wounds, classified their fractures into displaced and undisplaced types with the displaced type occurring in eighteen of the twenty cases. These findings therefore, concur with those of May's study. Most other studies of low velocity facial gunshot injuries do not mention the degree of the displacement of the fractures present other than referring to them as simple comminuted type fractures. These studies all show similar findings to the present study that comminuted type fractures were most commonly associated with low velocity facial gunshot injuries (Gant and Epstein, 1979; Rowe and Williams, 1985; Haug, 1989; Fonseca and Walker, 1991; Kihtir *et al.*, 1993; Tsakiris *et al.*, 1996). The hard tissue injuries were more common than the soft tissue injuries. This finding was consistent with other studies (Yao *et al.*, 1972; May *et al.*, 1973; Cohen, 1984; Gussack and Jurkovich, 1988; Williams *et al.*, 1988; Kihtir *et al.*, 1993).

Fig. 10 Orthopantomogram showing comminuted undisplaced fracture with fracture of 38

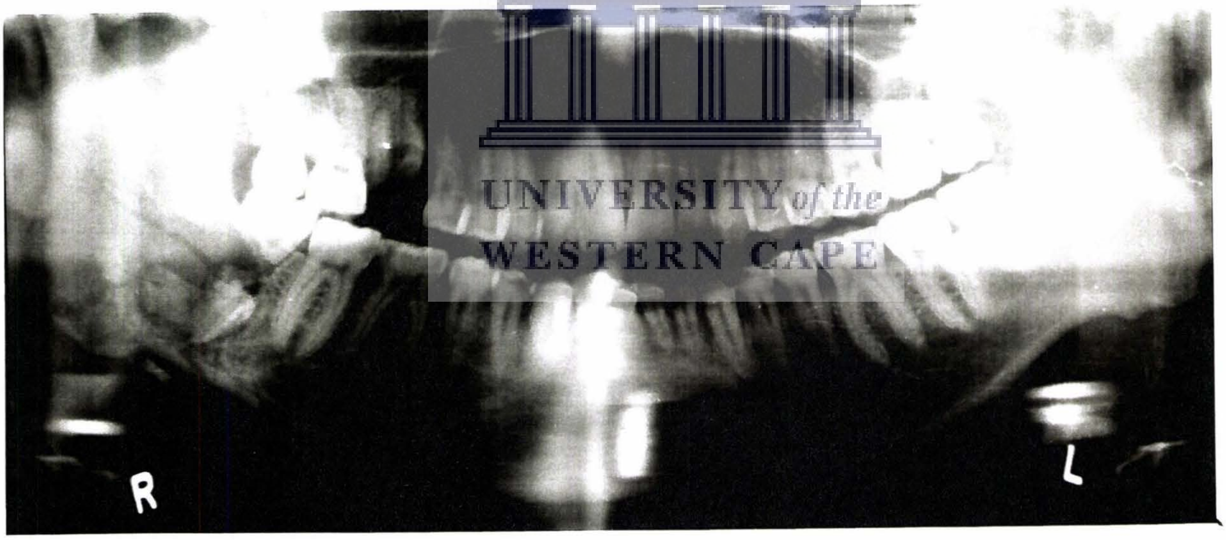


Fig. 11 Orthopantomogram showing comminuted displaced fracture

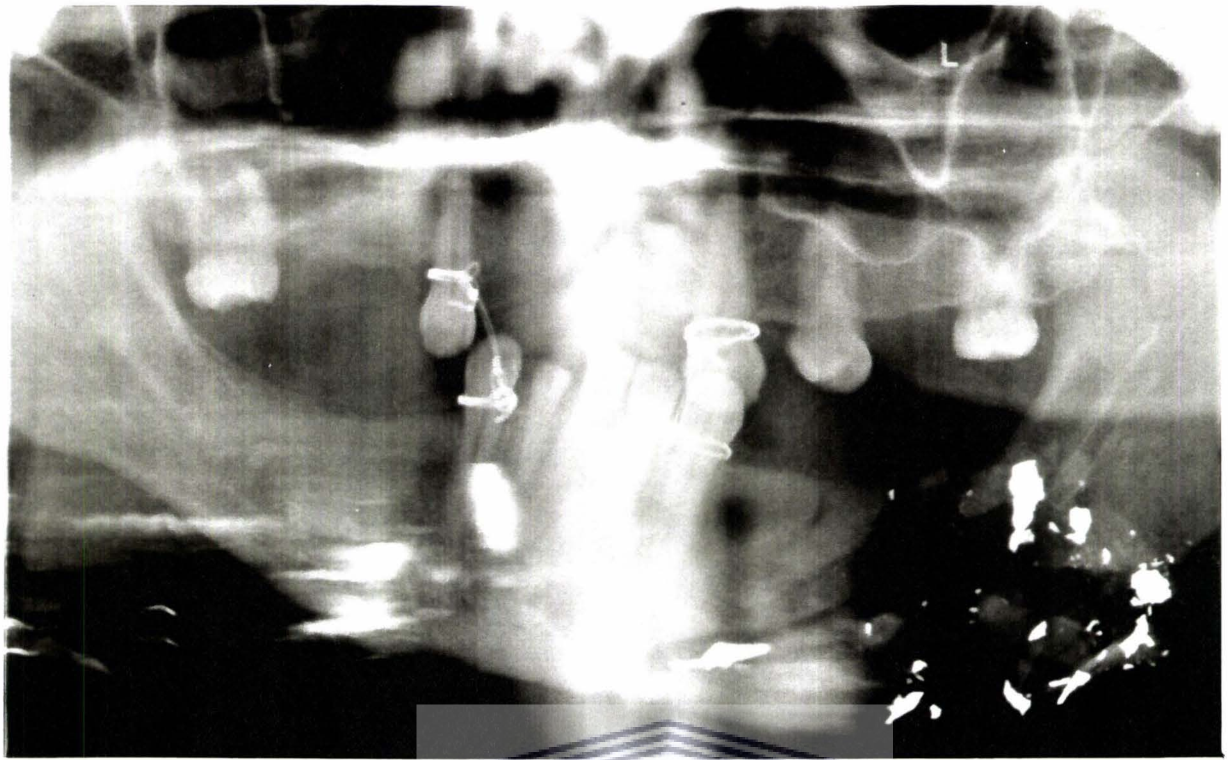
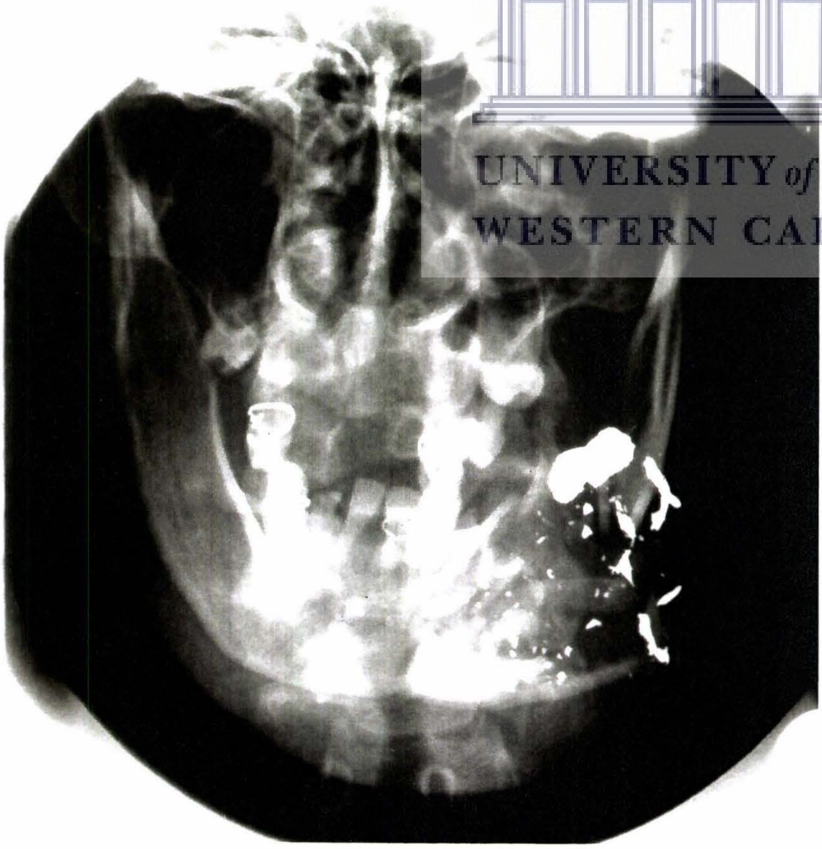


Fig. 12 PA mandible view showing comminution of bone



6.9. MANDIBULAR AND MAXILLARY FRACTURES AND THEIR DISTRIBUTION

The present study shows that mandibular fractures were more common than the maxillary ones with the comminuted displaced fractures being most frequent. Corresponding with this finding, is that fractures of the lower third of the face occurred in the majority of the cases. The fractures of the mandible were comminuted with varying degrees of displacement with the bony and tooth fragments acting as secondary missiles causing further soft tissue damage. In 56% of the cases of mandibular fractures, there was a combination of fracture sites involved. The angle, teeth, body, ramus and dentoalveolar areas of the mandible were most commonly affected. When the injuries involved the lower third of the face there was often tongue and pharyngeal swellings which were rarely life threatening although some patients presented with airway compromise and required appropriately tuned airway management. In some cases the body, angle region and condylar regions were completely shattered and these injuries often made the management complicated. Again the severity of the injuries depended on the ballistic principles and resulting wounding effects mentioned previously.

The maxillary complex fractures were generally less severe than the mandibular ones. This is probably due to the relatively thin nature of the bone allowing the bullet to pass through rather than being stopped, thereby transferring most of its energy to the bone and causing more severe damage. The zygomatic fractures were often associated with condylar and maxillary sinus fractures. This finding was similar to that of Cohen's (1984) study. Occasionally, the bullet traversed the palate and caused an oro–nasal and oro–antral communication. In 31% of the maxillary fractures, the orbit and its contents were involved with varying degrees of severity (*see later*). In 53% of the maxillary fractures, there were a combination of fracture sites involved with the dentoalveolar, teeth, sinuses, orbit, zygomatic and palatal areas being commonly involved. The classic Le Fort classification (Rowe and Williams, 1985) of maxillary fractures were relatively uncommon.

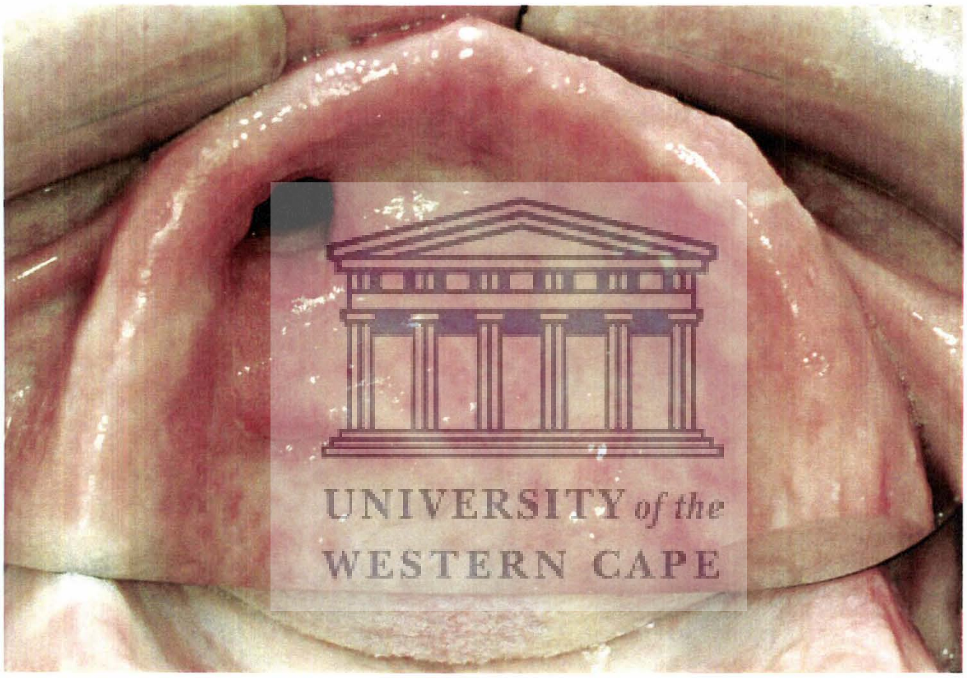
The undisplaced fracture types both simple and comminuted occurred more frequently in the mandible and the comminuted displaced fractures occurred more often in the maxilla than the mandible. Again, this can be attributed to the fact that the maxillary bone is less dense than the mandibular bone thereby offering less resistance to the missile and causing more displacement of bone.

In the study undertaken by May *et al.* (1973), displaced mandibular fractures were more common than the undisplaced ones with the angle and the symphysis regions being the most frequent sites affected.

Neupert III *et al.* (1991) in their study of 32 cases of low velocity gunshot injuries to the mandible, reported that fractures were observed throughout the mandible with no preferential site of injury but with a combination of fracture sites observed in 31% of their sample.

Kihtir *et al.* (1993), observed that the maxillary fractures were more frequent than the mandibular ones although a combination of fracture sites predominated. These findings highlight the fact that the pattern and distribution of missile injuries affecting the hard tissues are often unpredictable with the common factor being comminution of the bone and teeth.

Fig. 13 Entrance wound through the palate causing an oro–nasal fistula

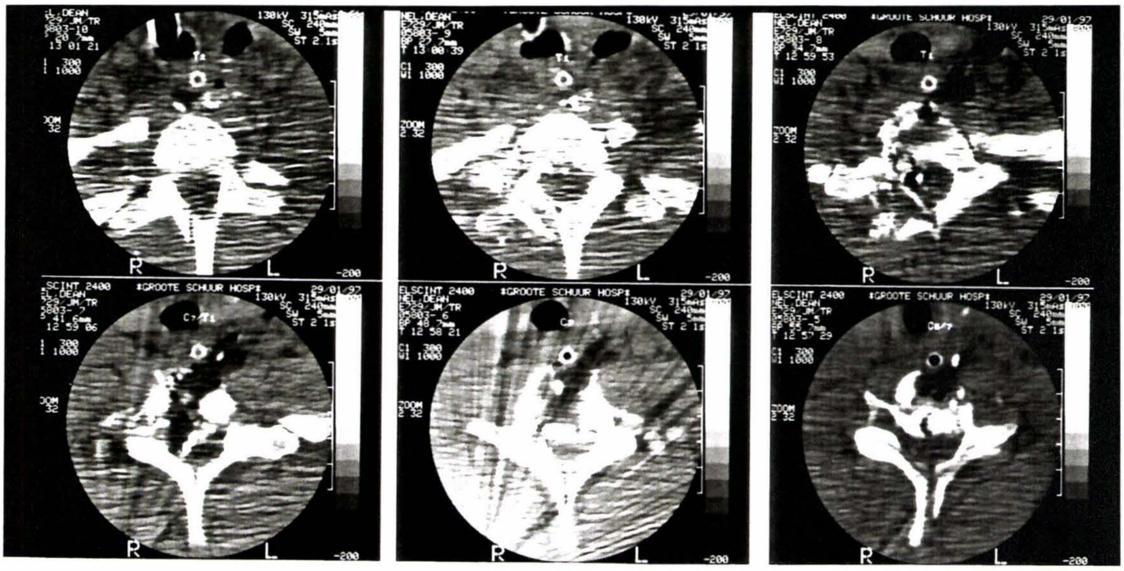


6.10 ASSOCIATED INJURIES

Associated bodily injuries that present with concomitant maxillofacial gunshot injuries are variable (Rowe and Williams, 1985). In the present study, head injuries were the most frequent, all with associated depressed levels of consciousness. Associated limb injuries especially involving the upper limbs and shoulder region and neck area were fairly frequent, occurring in approximately 20% of the cases. Remote organ injuries e.g. thoracic and abdominal injuries were less frequent. Kihtir *et al.* (1993), reported the intracranial injury as being the most common associated injury with remote organ injury being less frequent. They also reported a 4% mortality from these injuries. A depressed level of consciousness was associated with 56% of their patients with head injuries. This finding is in contradiction to the present study. Intracranial injuries are commonly associated with injuries to the mid third of the face. Rowe and Williams (1985) stated that a closed head injury should not be excluded when assessing patients with maxillofacial gunshot injuries especially to the mid and upper facial regions. The severity of the intracranial damage can vary from a closed head injury to permanent neurological damage in certain instances depending on the path of the missile (Gant and Epstein, 1979). This often results from either direct penetration of the bullet into the cranium or from the shock wave produced by the temporary cavity (Rowe and Williams, 1985). Gant and Epstein (1979) also stressed that entrance wounds to the supraorbital area require careful examination of the central nervous system and the cranial nerves in order to establish an early diagnosis of a neurological injury. Together with a careful neurological examination, special attention should be directed to the orbits and their contents as well as the patient's visual function especially with midfacial missile wounds. The associated limb injuries were commonly associated with exit wounds from the mandibular region with re–entrance of the bullet into the shoulder or the upper limb. In one case of an intentional assault gunshot wound to the face, the patients forefinger was avulsed in an attempt to protect the facial region.

Fig. 14 Avulsion of forefinger

Fig. 15 CT–Scan — axial views showing shattering of the bodies of the cervical vertebrae from a resultant gunshot injury to the face



The neck injuries were often associated with a high suspicion of vascular injuries especially of the carotid and jugular vascular systems. These injuries included associated injuries to the cervical vertebrae with or without neurological sequelae. These associated cervical spinal injuries were commonly associated with gunshot injuries to the lower face and neck region. This finding was supported by that of Kihtir *et al.* (1993). The present study also shows an involvement of a combination of associated anatomical sites other than those within the maxillofacial region in 27% of cases. These were as a result of multiple gunshot wounds to the face and body.

6.11 SPECIAL INVESTIGATIONS

Conventional plain film radiographs were requested in 59% of the sample. In 9% of the reported cases, no special investigations were requested. These represented cases that were isolated to the soft tissues with no underlying hard tissue injuries. With the emphasis on cost saving at our local state hospitals, the attending clinician opted not to request any radiographic investigations since the trajectory of the missile affected only the soft tissues with no damage to the underlying skeletal structures.

The conventional plain film radiographs included:—

(a) **Skull radiographs —** both anteroposterior and lateral views.

(b) **Facial radiographs —** which included occipitomental views 0°; 15° and 30° views, orthopantomograms and an anteroposterior view of the mandible. Further specialized radiographs of the facial region were requested where the injury merited these. These included specialized views of the temporomandibular joints, orbito–naso–ethmoidal complex views (i.e. panoramic radiographs of these regions), submentovertex views to view the zygomatic arches and basal views of the skull.

(c) **Cervical spine radiographs —** these included lateral and anteroposterior views of the cervical spine region. The lateral view of the cervical spine also includes a soft tissue profile of the neck, the oesophagus and the pharyngeal airway.

Generally, the plain film radiographs together with a thorough clinical examination often indicated the trajectory of the bullet as well as the localization of secondary projectiles created by bullet fragmentation. The pre–operative evaluation of these facial gunshot injuries should be expedient and cost–effective. As in any traumatized patient, the initial management focuses on the airway management and ventilation, followed by the arrest of any haemorrhage. Standard plain film radiographs are usually then employed. More complex special investigations are then requested at a later stage where indicated. These findings are consistent with those of other studies undertaken (Yao *et al.*, 1972; Gant and Epstein, 1979; Cohen, 1984; Rowe and Williams, 1985; Gussack and Jurkovich, 1988; Fonseca and Walker, 1991; Dolin *et al.*, 1992).

Other specialized investigations included computer tomography and angiography. Carotid angiograms were requested where a vascular injury was suspected. In the present study, these were requested in a vast majority of patients with associated neck injuries. Vascular injuries are more commonly associated with injuries to the lower third of the face and a high index of suspicion is always necessary. Therefore most authors suggest angiographic studies should be routinely performed if the bullet trajectory suggests a carotid injury, or if a large haematoma or rapid bleeding is noted (Gussack and Jurkovich, 1988; Kihtir *et al.*, 1993). In some patients with severe bleeding from the external carotid artery or its branches, angiography and embolization may effectively control the haemorrhage (Dolin *et al.*, 1992).

Controversy still exists as to the management of a missile which has not exited but is retained within the tissues. Some reports in the literature have stressed the potential danger of retained small missile fragments within the neck area. These fragments, if lying close to the major vessels, may cause secondary haemorrhage or traumatic aneurysms with delayed complications (Yao *et al.*, 1972). Other reports of lead poisoning and infection have also been reported (Rowe and Williams, 1985). Very often, extensive surgery is required to remove foreign bodies which are often in close proximity to vital structures in the neck e.g. the spinal cord and carotid vasculature. In these cases, the foreign body is best left alone and should be observed radiographically for evidence of any movement.

Gunshot wounds of the face mandate careful neurological examination. In certain instances the neurological examination does not necessarily reveal the resulting intracranial or spinal injuries present. Likewise plain film radiographs do not always reveal resulting skull and spinal injuries. Therefore most studies reviewed, suggest that mandatory computer tomography scans be done especially when the trajectory of the missile injury involves the upper and middle third of the face (Yao *et al.*, 1972; Dolin *et al.*, 1992; Kihtir *et al.*, 1993). Likewise in the present study, head injuries were the most common associated injuries and therefore computer tomography scans were requested in 81% of these patients. These scans also provided a baseline study in order to compare repeat computer tomography scans taken for patients with deteriorating neurological status.

Further specialised 3–D reconstruction computer tomography scans were requested in a fewer patients where reconstructive procedures were complicated.

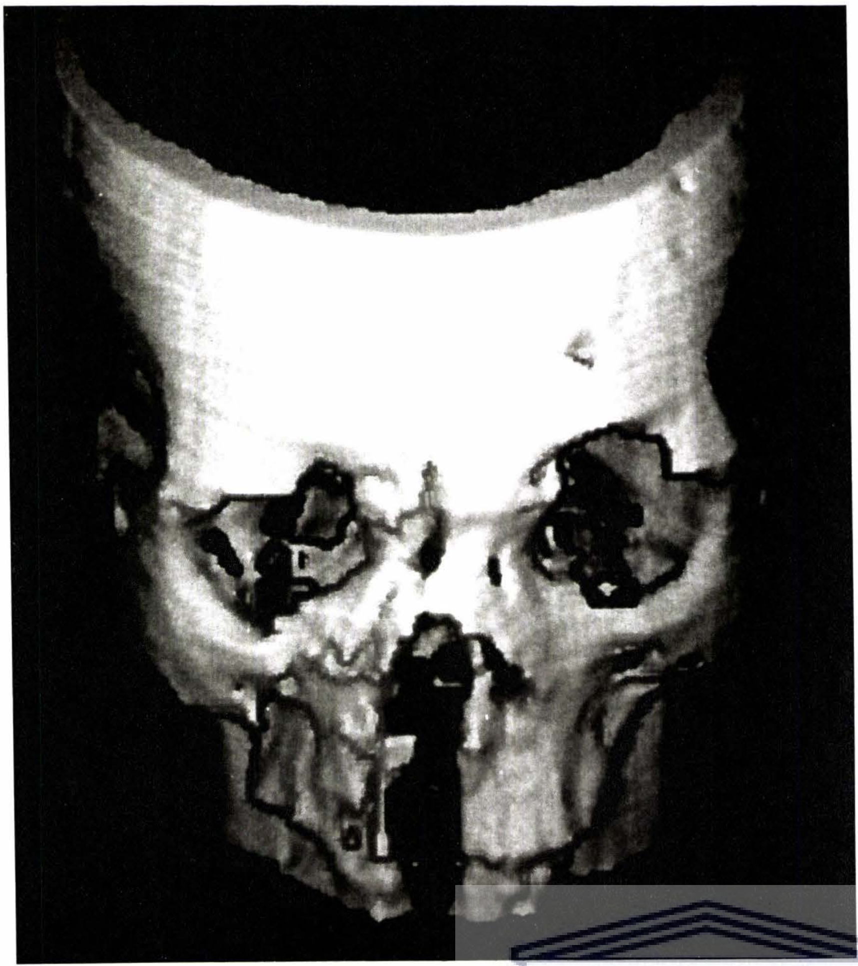


Fig. 16 3D — Reconstructed CT–Scan showing skeletal damage caused by an attempted suicide

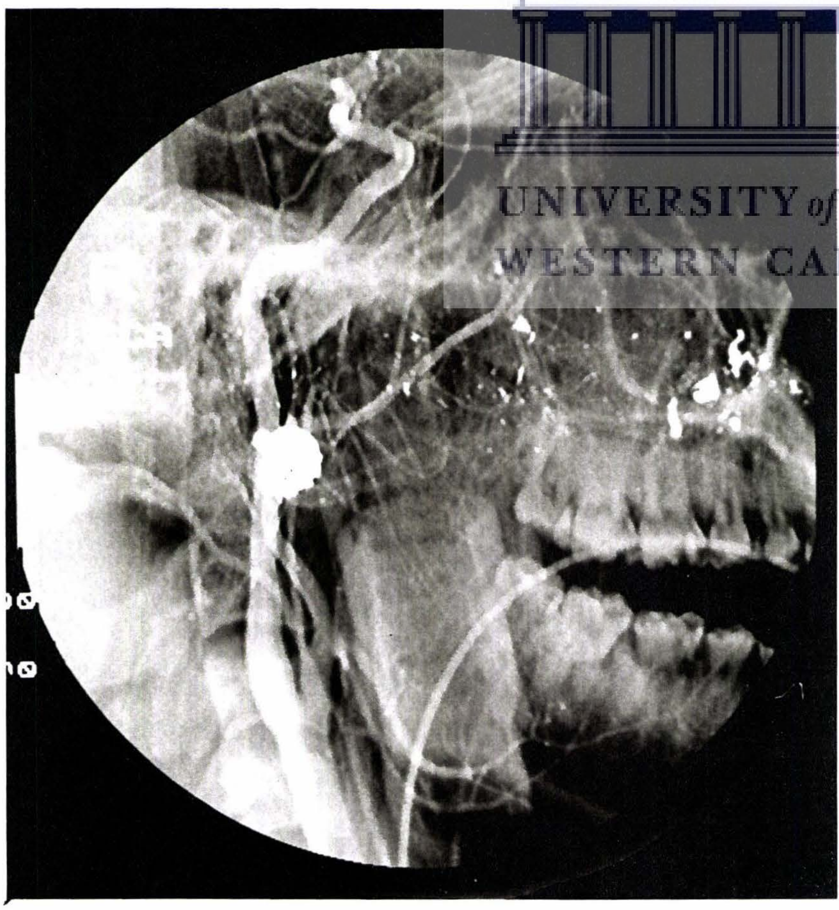


Fig. 17 Carotid angiogram showing proximity of lead fragment to common carotid artery

6.12 TREATMENT PRINCIPLES

The initial assessment and resuscitation of the patient sample with facial gunshot wounds were carried out according to the advanced trauma life support guidelines set down by the American College of Surgeons. These patients are usually seriously injured and require rapid assessment of the injuries and institution of life–preserving therapy. These guidelines include:—

(a) Airway maintenance with cervical spine control which is assumed in all cases and the patients are kept immobilized until a spinal injury is ruled out radiologically. Because of the special nature of these injuries, particular attention is paid to the airway control.

(b) Breathing and ventilation.

(c) Circulation with haemorrhage control.

(d) Disability which includes an assessment of the neurological status of the patients.

(e) Exposure/Environmental control — which involves undressing the patient and full head to toe examination to check for any associated bodily injuries.

The initial assessment of these patients were instituted by the attending trauma officer.

6.13 AIRWAY CONTROL

The decisions concerning airway management i.e. whether a patient required intubation and the method of airway control to be used were made by the trauma officer. There is a tendency to aggressively control the airway before symptoms of airway compromise occur. In general, the airway is controlled on any patient who is (1) haemodynamically unstable; (2) has an injury at a high spinal cord level; or (3) has clinical evidence of a head injury. In addition, patients are intubated with moderate size haematomas in the neck or face and any patient with a significant amount of intraoral blood. The above principles were applied to those patients with airway compromise although the majority of the patients (86%) required no airway management. Oral and nasoendotracheal intubations were instituted in 4,3% of patients. Elective tracheostomies were done in 3,3% of the patients with airway compromise. Emergency cricothyroidotomies were performed in 5% of cases with compromised airways resulting from excessive bleeding, tongue and floor of mouth swelling and in cases with expanding haematoma's especially of the neck region. The patients with airway compromise generally included those gunshot injuries affecting the lower third of the face usually where the missile traversed floor of the mouth, tongue and pharynx region. The general indications for airway control concur with those of other studies done (Yao *et al.*, 1972; Joy *et al.*, 1973; May *et al.*, 1973; Gant and Epstein, 1979; Zide and Epker, 1979; Rowe and Williams; 1985; Williams *et al.*, 1988; Neupert III *et al.*, 1991; Dolin *et al.*, 1992; Tsakaris *et al.*, 1996).

The above mentioned studies are also in agreement with the findings of the present study that:—

(1) Most persons were able to maintain an adequate airway by conservative measures of suctioning of the oral cavity, patient positioning and occasional protraction of the tongue.

(2) In those patients requiring emergency control of the airway, endotracheal intubation is the initial treatment of choice.

(3) When the endotracheal intubations were unsuccessful, a cricothyroidotomy is the emergency treatment of choice.

(4) When indicated, a tracheostomy was best performed electively in the operating room after initial airway control by either an intubation or a cricothyroidotomy.

(5) Extubations of these patients were only considered once the pharyngeal swelling was decreased and assessed by having the patients breathe around a deflated cuff of the endotracheal tube. Occasionally prolonged airway control was maintained by means of a tracheostomy so that necessary surgical treatment could be facilitated.

(6) Most studies also concur that the airway should be assessed every 12 hours and the patients were generally extubated after 48 hours following the initial injury.

6.14 SURGICAL TREATMENT

6.14.1 Soft tissue management

The majority of patients in the present study had early soft tissue debridement. In the soft tissue injuries as mentioned before varied from small localized entrance wounds with surrounding ecchymosis together with ragged edges. The exit wounds were generally larger in size and often presented with ragged or stellate type wounds. With closer range injuries, more avulsive type exit and entrance wounds were present. Depending on the site of these entrance and exit wounds, the treatment varied from local soft tissue debridement together with copious washing out of the wound tracts with a Betadine solution. All necrotic tissue, fragments of clothing, tooth, bone and missile chips were removed, haemostasis achieved and a decision as to whether these wounds be closed primarily, secondarily or dressed were made. The larger avulsive wounds were generally debrided and closed primarily or secondarily. The majority of the patients in the present study with avulsive type wounds had initial debridement together with open packing of the wounds with BIPP and secondary local or distant soft tissue flaps. The distant flaps were free non–vascularized flaps.

Haug (1989) suggested that cutaneous injuries be treated as abrasions or burns. These should be cleansed with an antiseptic or saline wash and dressed with an antiseptic ointment e.g. Betadine. They also suggest that the permanent cavity be irrigated with copious amounts of normal saline to remove the foreign debris, necrotic tissue and to reduce the concentration of bacteria. Most of the earlier international studies undertaken (Yao *et al.*, 1972; Joy, 1973; Zide and Epker, 1979; Rowe and Williams, 1985; Williams *et al.*, 1988) all support the idea of early initial soft tissue debridement and primary closure of soft tissue wounds with local flaps. For the larger avulsive wounds, secondary closure with distant flaps or split skin grafts were undertaken at a later stage. The management of soft tissue injuries in the present study were in keeping with those of the international studies undertaken.

Fig. 18 Gauge packing of exit wound

6.14.2 Hard tissue management

The present study indicates that the mandibular fractures were more common than the maxillary ones. The comminuted type fractures predominated with the comminuted displaced fracture being the most common. Both the simple and comminuted displaced fractures comprised a total of 44% of the patients with fractures. The simple and comminuted undisplaced fractures comprised 35% of the sample. Considering this fact, more open reductions and fixations were performed in both the mandibular and maxillary fractures. Generally, the undisplaced fractures were treated by means of closed reductions or in certain cases were treated conservatively. The treatment of the mandibular fractures by means of closed reductions comprised of the placement of either interdental eyelet wiring or erich type arch bars and the placement of intermaxillary fixation for a period of four to six weeks (i.e. in dentate cases).

Closed reductions of the maxillary fractures were confined to maxillary dentoalveolar fractures, Hemi–Le Fort fractures, mildly displaced or undisplaced Le Fort I and II fractures and splitting of the palate. These usually involved the placement of Erich type arch bars and intermaxillary fixation was applied for a period of four to six weeks. Displaced fractures of the edentulous mandible were generally treated by means of open reductions with rigid internal fixation by means of titanium miniplates or by means of semi–rigid internal fixations using transosseous stainless steel wiring.

Closed reductions using Gunning splints were employed in a few cases of grossly comminuted displaced fractures of the edentulous mandible. Although this approach still has some merit in maintaining the vascularity of the pedicled small fragments of bone, the impedicled fragments often lead to sepsis or are resorped. Therefore, there appears to be a decreased tendency in doing closed reductions of this type. Presently, these fractures are managed by doing a wide early debridement together with the placement of a long bone spanning titanium reconstruction plate via an open reduction. A secondary procedure is done approximately three to four weeks later where the bone loss is replaced using an autogenous bone graft usually corticocancellous bone from the ilial crest.

Undisplaced, minimally mobile or non–mobile fractures of the mandible or the maxilla were usually treated conservatively. Amongst the open reduction procedures, semi–rigid fixation by means of internal fixation using stainless steel transosseous wiring was employed more commonly than rigid internal fixations using titanium miniplates. Open reductions with a combination of both plating and wiring were more commonly employed than plating alone. The reason for the aforementioned was that plates were considered to be less cost–effective than using wires. No external fixations were used. This was probably due to the fact that adequate reductions and fixations of most types of fractures could be obtained using standard intraoral techniques.

Considering that the injuries were confined to low and intermediate missile injuries, the bone loss apparent was usually less than four cm in length and therefore autogenous bone grafting usually non–vascularized bone grafts harvested from the ilial crest were used. These were normally placed in two to three weeks post injury once the bony defect was more accurately defined. No vascularized bone grafting was employed. This was probably due to the fact that in most cases the bony defects were not large enough to warrant the usage of vascularized grafts since these procedures are technically difficult, time consuming and requires more extensive surgery.

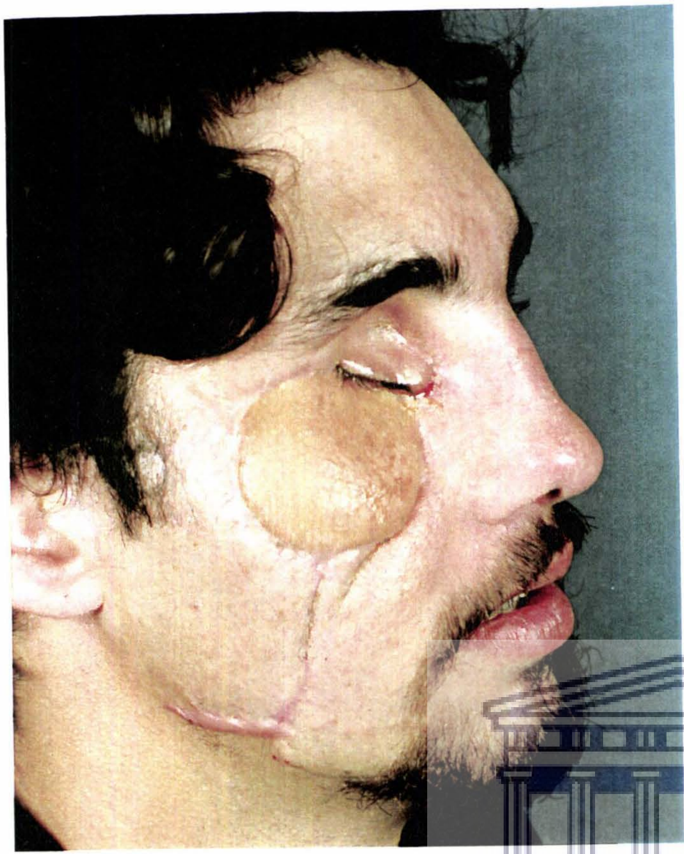
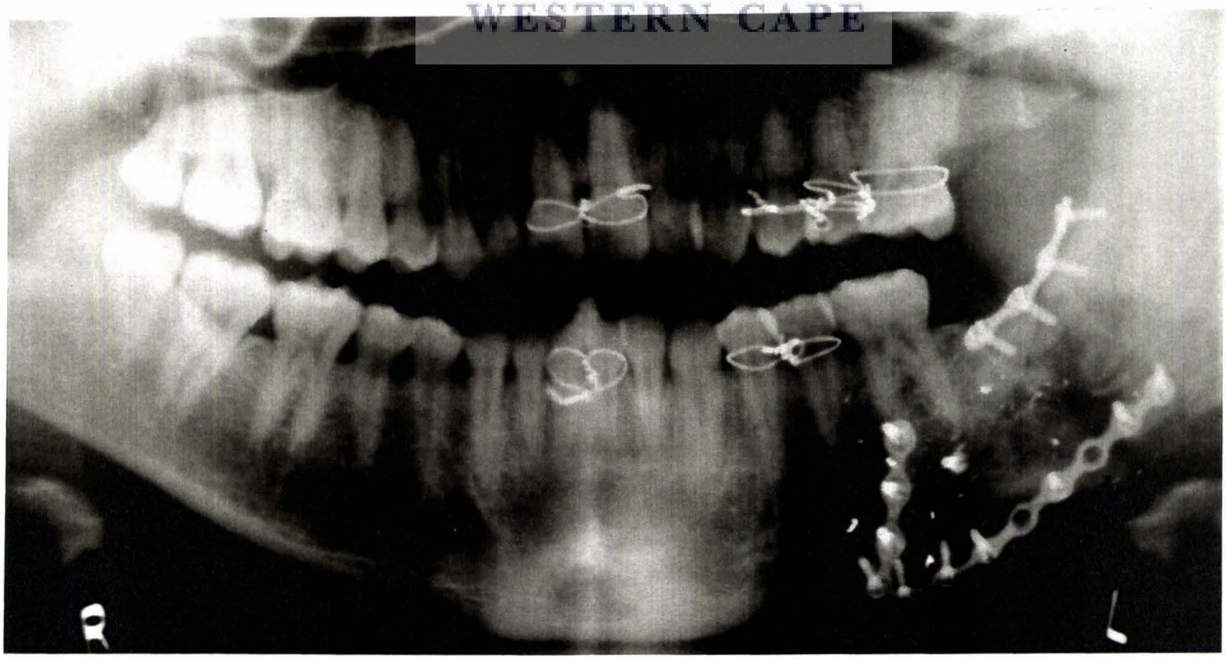


Fig. 19 Non–vascularized abdominal flap used to close soft tissue defect

Fig. 20 Orthopantomogram showing open reduction and plating of fractured mandible



6.14.3 Timing of fracture management

More fractures were treated immediately i.e. within 12 hours of presentation. The reason for this was due to the fact that most of these patients often required a general anaesthetic at presentation and therefore the definitive treatment was carried out. There was however little significant difference between those cases that required immediate and delayed treatment. Fracture management was often delayed due to the fact that adequate facial radiographs were unavailable at presentation, the facial swelling or intraoral swelling were too excessive or the intraoral swelling often hindered the airway and prevented the placement of intermaxillary fixation immediately.

Many of the local and international studies undertaken (Yao *et al.*, 1972; Joy, 1973; May *et al.*, 1973; Gant and Epstein, 1979; Zide and Epker, 1979; Cohen, 1984; Rowe and Williams, 1985; Gussack and Jurkovich, 1988; Williams *et al.*, 1988; Fonseca and Walker, 1991; Neupert III *et al.*, 1991; Dolin *et al.*, 1992; Fleming *et al.*, 1993; Kihtir *et al.*, 1993; Tsakiris *et al.*, 1996) all agree that with low velocity gunshot injuries to the face, initial conservative soft and hard tissue debridement should be carried out early (i.e. usually within 12 hours of presentation), all favouring closed reductions with retention of most of the viable chips of pedicled bone and application of intermaxillary fixation. Most of these authors report low incidences of post treatment complications such as infection with the above method of treatment. They also agree that conservative soft tissue debridement should be employed in most cases with meticulous attention given intraoral closure with usage of local flaps if necessary to obtain an intraoral watertight seal of the mucosa to prevent septic complications. These authors support the usage of closed reductions in grossly comminuted displaced fractures of both the mandible and the maxilla with few reported cases of post operative complications. May *et al.* (1973) reserved open reductions for cases where closed reductions generally failed. Neupert III and Boyd (1991) treated their fractures of the coronoid process, ramus and condylar regions by means of closed reductions with no infective complications. The angle, body and symphyseal fractures of the mandible were treated by means of open reductions with a complication rate of 27% related mostly to the dentoalveolar structures and were controlled by simple methods of local sequestrectomy, extraction of the indicated teeth and the usage of antibiotics. They however make no mention of the degree of displacement or comminution of these fractures.

The studies above also agree that fragment of teeth should be removed and those teeth attached to viable dentoalveolar structures should be maintained and stabilized by the usage of erich arch bars with a close follow up regarding the vitality of these teeth.

The present study supports the idea of conservative local soft and hard tissue debridement together with the usage of closed reductions where possible, but a more aggressive approach with wide local open reductions and internal fixations using wires and plates being employed especially recently with a reported post operative complication rate of 19% which is relatively low.

Recently, especially the American studies undertaken by (Manson, 1985; Finch and Dibbell, 1979; Gruss, 1990; Gruss *et al.*, 1991; Thorne, 1992) all support the idea of primary hard and soft tissue repair with extended open reductions and rigid fixations of both low and especially high velocity avulsive injuries. These studies all report low post operative infection rates. One must also consider that follow up periods were relatively short (up to two years).

It must be mentioned, however, that the advantages of open reductions with rigid internal fixations with plates are being realized by most oral surgeons with obviating the necessity of intermaxillary fixations and making external fixations obsolete.

6.15 ANTIBIOTIC TREATMENT

All gunshot wounds are contaminated. These wounds are also compound intra– and extra–orally. Most authors agree that prophylactic antibiotics are indicated for facial gunshot wounds (Joy, 1973; May *et al.*, 1973; Gant and Epstein, 1979; Haug, 1985; Rowe and Williams, 1985; Neupert III and Boyd, 1991). A broad spectrum antibiotic effective against anaerobic and gram–negative bacteria is indicated. Generally the usage of penicillin or clindamycin is generally accepted together with the usage of cephalosporins, erythromycin as secondary alternatives. Metronidazole is generally used as an adjuvant to this prophylactic antibiotic therapy since it is effective against anaerobic organisms resident intraorally. The usual considerations for penicillin–resistant organisms must also be considered and often the clinicians judgement must be used to decide on the appropriate regimen and period of antibiotic treatment must be used.

The above authors also agree that anti–tetanus prophylaxis is essential in facial gunshot wounds since tetanus can have its genesis from many foreign bodies e.g. contaminated bullets, clothing fragments or wounds soiled with dirt or rust particles. Although the face has an abundant blood supply that can often eliminate the culture medium for organisms causing gas gangrene within necrotic dead muscle, no wound is too minor to accept a tetanus infection (Zide and Epker, 1979).

Adhering to the above principles, the present study shows that most patients received prophylactic antibiotics on admission up to 48 hours post operatively with 31% of the sample receiving oral antibiotics for longer than one week post operatively. Penicillin was the most commonly used antibiotic either intravenously, intramuscularly or orally. Clindamycin and Cephalosporins were used as secondary alternatives. Metronidazole given orally or rectally was often used as an adjunctive antibiotic. All the patients with isolated soft tissue injuries received a stat dose of intramuscular penicillin. All the patients with facial gunshot wounds received 0.5ml of tetanus toxoid prophylaxis given intramuscularly on admission.

6.16 HOSPITALIZATION

In the present study, 69 patients were discharged on the day of initial presentation. These were confined to those presenting with minor isolated soft tissue and bony injuries that were treated primarily. The rest of the sample were hospitalized for longer than one day with a mean hospitalization stay of six days. The majority were hospitalized for up to ten days. The patients who were hospitalized for a period longer than ten days had usually:—

(1) Complex gunshot injuries requiring multiple surgical interventions.

(2) Those presenting with initial airway compromise requiring intubation and often prolonged intensive care management.

(3) Those patients who had associated injuries e.g. head injuries with neurological deficit.

(4) Those having primary or post treatment complications e.g. sepsis.

(5) The patients with self inflicted gunshot injuries often required psychiatric or psychological evaluations and treatment prior and post surgical treatment and were only discharged once they were psychologically stable. Their injuries are also more complex due to the fact that they are closer range avulsive injuries. A total of 28 patients were hospitalized between 11 and 30 days.

With a major emphasis on cost savings at the local state hospitals, the total hospitalization of these traumatized patients was a major factor. Therefore where possible, early effective treatment protocols were instituted keeping cost in mind. May *et al.* (1973) in their study reported a shortest hospital stay of two days and the longest up to ten days. This study however was confined to low velocity gunshot injuries of 20 cases affecting the mandible only.

Most other studies from the developed first world countries do not mention the hospitalization aspect of their studies. Here one has to assume that the financial aspect of their treatment protocols are of a lesser concern. The hospital stay amongst patients with self– inflicted gunshot injuries, however, appear to be an important consideration (Shuck *et al.*, 1980; Denny *et al.*, 1992).

Shuck *et al.* (1980) reported a prolonged hospital stay of up to 20 days in their study regarding self–inflicted facial gunshot wounds. This finding was in keeping with that of the present study.

Denny *et al.* (1992) emphasizes that a shorter hospital stay of up to 13 days was achieved in their study of complex self–inflicted gunshot wounds due to early aggressive treatment using a combined multidisciplinary approach and applying treatment protocols suggested by recent studies undertaken by Gruss *et al.* (1991).

6.17 COMPLICATIONS

The present study reports a complication rate of 60% with 86% of these complications presenting early (i.e. up to one week) and 14% presenting later than one week up to an average of three months post treatment. The probable reason for the lower rate of later presenting complications was due to the relatively short post operative follow–up period which was limited to one month in most cases. If the treatment outcome was satisfactory up to one month post operatively, the patients were discharged and presented again once complications e.g. sepsis occurred.

6.18 TYPES OF COMPLICATIONS

6.18.1 Sepsis

The reported post operative sepsis rate was 19% in the present study. These patients with septic complications presented both early and late. The reasons for these infectious complications are variable and numerous ranging from inadequate debridement to improper surgical techniques. The literature reviewed all report variable rates of infection but most studies concur that high local complication rates occur in the presence of grossly displaced fractures occurring together with intraoral injuries. Yao *et al.* (1972) reported a local septic complication rate of 25% and Kihtir *et al.* (1993) 33% in their study. Most studies generally agree that more post operative septic complications occurred in patients who had open reductions especially for displaced fractures than those who had closed reductions (Zide and Epker, 1979; Neupert III *et al.*, 1991; Fleming *et al.*, 1992; Kihtir *et al.*, 1993). Gruss *et al.* (1991) also reported that primary soft and hard tissue reconstruction in the midface is usually the cornerstone of repair, but this approach to mandibular defects often has a high complication rate. This is because the mandibular repair has in the path of the salivary stream, an even minor degree of exposure or contamination from the oral cavity will lead to severe infection, often necessitating removal of the bone grafts. They therefore recommend delayed secondary bone grafting using rigid mandibular reconstruction plates.

The reported sepsis rate in the present study is relatively high and probably due to more extended open reductions being done. Together with these open reductions, there is usually extended periosteal stripping with resultant devitalisation of bony fragments. This, therefore provides a nidus for infections. The present study also reports osteomyelitis occurring in 19% of the patients with septic complications. These often led to bony non–unions, malunions or fibrous unions which following aggressive local debridements often led to bony contour defects.

Generally, the infection rate is low in civilian gunshot injuries in contrast to higher velocity injuries which often require aggressive debridement of devitalized tissue and delayed wound repair (Kihtir *et al.*, 1993). Judicious but conservative debridement is usually the rule. If there is a question of the viability of the tissue or bone, it should be left in situ. The rich blood supply of the face often allows conservative debridement of low velocity facial gunshot wounds.

The duration of the antibiotic therapy did not seem to influence the incidence of local septic complications in this study. This finding is in keeping with that of Kihtir *et al.* (1993). Most of the reported infectious complications in the present study occurred when intraoral wounds were present and often dehisced post operatively and when non–viable teeth or root fragments were present. Again this finding concurs with those studies undertaken by (Neupert III *et al.*, 1991; Fleming *et al.*, 1993; Kihtir *et al.*, 1993).

Fig. 21 Tissue breakdown of wound due to sepsis

6.18.2 Limitation of mouth opening

This was the second most common reported complication occurring both early and late. Zygomatico–coronoid ankylosis occurred in two cases presenting one month post treatment. One case of temporomandibular joint ankylosis following a direct gunshot to the condylar head. This complication occurred when the zygomatic arch and bone, the dentoalveolar segment of the maxilla and the coronoid process were grossly comminuted. The causes for the limited mouth opening were (a) trismus due to muscle injury; (b) trismus occurring following prolonged periods of intermaxillary fixation resulting in disuse muscle atrophy; and (c) mechanical interferences resulting from fibrous or bony ankylosis in the condylar or zygomatico–coronoid region (Neupert

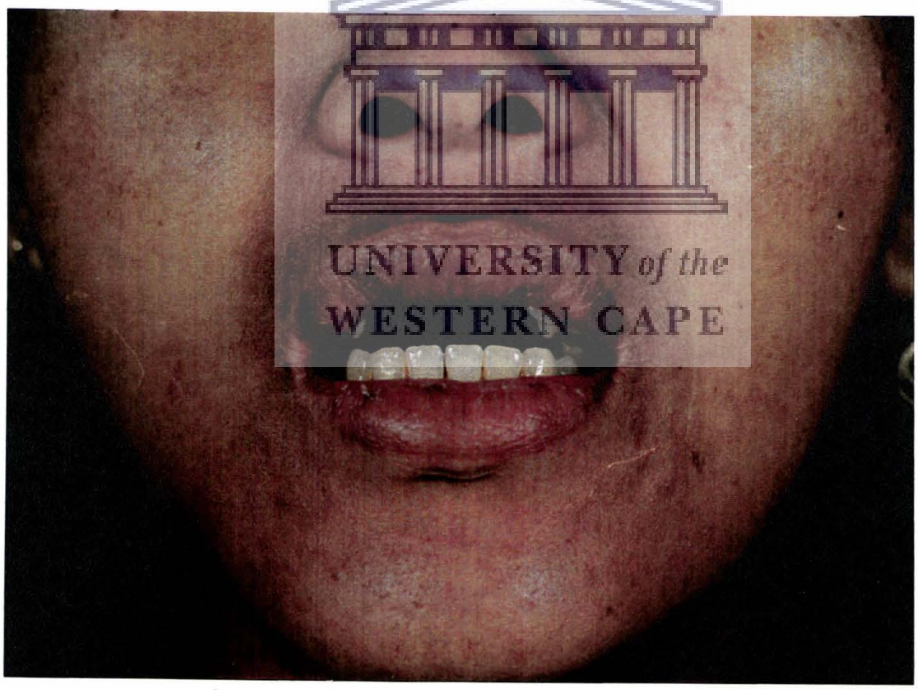
III *et al.*, 1991). The trismus resulting from damage to the muscles of mastication or from prolonged intermaxillary fixation usually resolved spontaneously with mouth opening exercises. There was an equal distribution of both early and late complications leading to a limitation of mouth opening.

The rate of post operative ankylosis reported was low and these findings are in keeping with the literature reviewed (Rowe and Williams, 1985; Fleming *et al.*, 1993). The remaining causes for the reported limitation in mouth opening were due to (1) direct damage to either the masseter, pterygoid and temporalis muscles occurring in combination with fractures of the condyle, coronoid process, angle and ranial regions of the mandible; and (2) from mechanical interferences associated with condylar and subcondylar fractures. There were few reported cases of limitation of mouth opening resulting from prolonged use of intermaxillary fixation. Surprisingly, there are few reported cases of limitation in mouth opening as a complication in the literature reviewed. Fleming *et al.* (1993) reported two cases of bony ankylosis occurring out of 39 cases of facial gunshot wounds reviewed.

Neupert III *et al.* (1991) report that limitation of adequate normal mouth opening (>40mm) occurred in most cases of the group comprising fractures of the coronoid process, ramus and condylar regions. They also report that this complication was relatively high in their sample due to poor follow up of these patients. For compliant patients, they instituted a rigorous long–term programme (as long as six months) comprising of physiotherapy including both active and passive range of motion exercises together with patient education and the use of stabilization devices allowing early mandibular mobility.

Banks (1985) mentioned that fibrous and bony ankylosis can occur commonly in facial gunshot wounds especially with comminuted fractures of the ramus of the mandible, the adjacent maxilla and the mandibular condyle. He mentioned that this can be avoided by judicious surgical removal of obstructing tissue at the early initial stage of treatment. It is therefore, noteworthy to mention the relatively high rate of limitation of mouth opening especially as an early complication can be attributed to a poor follow–up (up to one month) of the present patient sample.

Fig. 22 Limitation of mouth opening

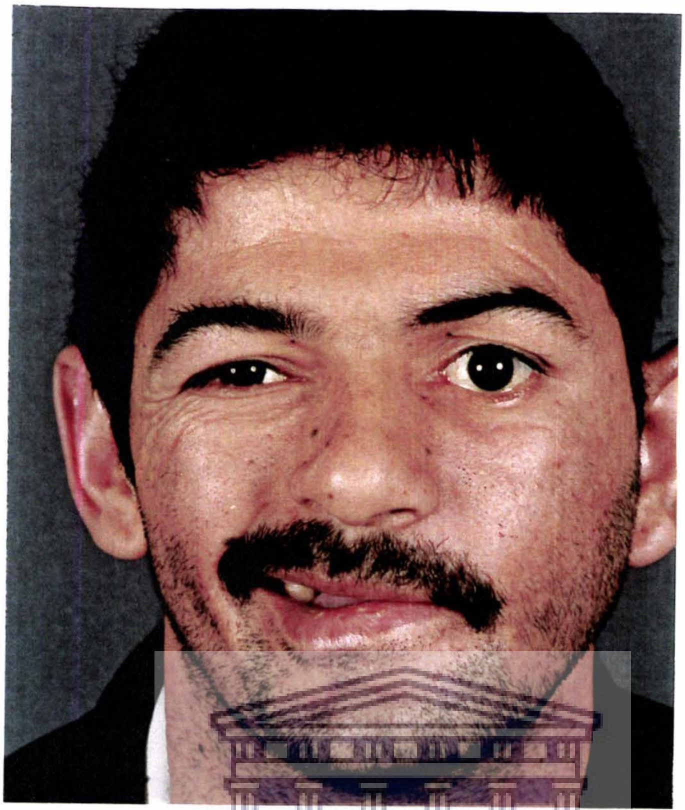


6.18.3 Neurological complications

This was the most common reported complication in the present study. Here damage to the facial nerve was reported in 26% of the patients with neurological complications followed by damage to the inferioralveolar nerve which occurred commonly with grossly comminuted displaced fractures of the mandible. Most other studies reviewed (Yao *et al.*, 1972; Gant and Epstein, 1979; Zide and Epker, 1979; Shuck *et al.*, 1980; Williams *et al.*, 1988; Haug, 1989; Dolin *et al.*, 1992; Kihtir *et al.*, 1993) all reported varying degrees of injuries to peripheral nerves with low velocity gunshot injuries with facial nerve injuries followed by injury to the mandibular branch of the trigeminal nerve occurring commonly.

In the present study, four patients had permanent damage to the facial nerve, two involving the main trunk of facial nerve where the bullet entered the angle of the mandible/mastoid area. Two patients had permanent damage to the marginal mandibular branch of the facial nerve. These nerve injuries were repaired at one month post injury with approximately 50% return of normal facial nerve function. The rest of the reported peripheral nerve injuries were transient and were treated conservatively. Haug (1989) reports that most neuropathies caused by low velocity gunshot wounds returns to normal spontaneously.

Fig. 23 Facial nerve palsy due to facial gunshot injury



6.18.4 Ocular injuries

Blindness was a complication in 26% of the sample usually caused by direct damage to the globe or by direct damage to the optic nerve. Of the remaining ocular complications, hyphaema was reported in 43% of the sample. The ocular complications were commonly associated with pellets from far range shotgun injuries and also from metallic fragments causing varying degrees of damage to the globe. Depending on the degree of damage, most of the patients sustaining scleral and corneal lacerations as well as vitreous haemorrhages reported improved visual activities subsequently. Yao *et al.* (1972) suggests that complete ophthalmological examination and subsequent timeous referral should be made to an ophthalmologist when an ocular injury was suspected. In most cases, sympathetic ophthalmoplegia seldom develops in less than ten days post injury, therefore, conservative treatment was preferred in the absence of infection, even when minimal sight was present. Other studies (Yao *et al.*, 1972; Kihtir *et al.*, 1993) report an ocular complication rate of approximately 11%. Our reported ocular complication rate was much higher (54% of all complications). Here one must consider that the present sample size is higher than those compared to the aforementioned studies undertaken by Yao *et al.* (1972) and Kihtir *et al.* (1993) which were usually less than one hundred. One could also assume that the associated ocular injuries were timeously assessed by both the trauma and maxillofacial surgeons and apt referral made to the opthalmologist. These ocular complications were therefore more accurately assessed.

6.18.5 Other complications

Of the remaining "other" complications, oro–antral communications, oro–nasal fistulae and parotid fistulae were reported in 6%, 3% and 2% of the sample respectively. The oro–antral communications were repaired primarily by using a buccal sliding flap. The oro–nasal fistulae were more complicated to repair and were repaired secondarily using a triple–layer closure described by Grotepass *et al.* (1990). This involves a creation of a nasal layer, an interpositional autogenous bone graft and the oral layer was formed either by local palatal flaps or using a tongue flap. Banks (1985) concurs that traumatic fistulae of the hard palate and the maxillary alveolus are a frequent sequel to transverse bullet wounds of the maxilla. He also stresses that every effort should be made to repair these wounds at the time of primary surgery. In the present study, this was possible in the oral–antral fistulae cases since they were usually small. In our experience however, the oro–nasal fistulae were more complicated and were usually initially packed openly using a BIPP gauze pack, followed by an obturator allowing the patient to feed initially and also allowing the defect to adequately delineate itself making a secondary definitive repair easier. Other studies reviewed (Yao *et al.*, 1972; Zide and Epker, 1979; Shuck *et al.*, 1990; Fleming *et al.*, 1993) all report a similar incidence of oro–antral and oro–nasal fistulae, also suggesting primary repair of these fistulae where possible. As found in the present study, Shuck *et al.* (1990) and Zide and Epker (1979) concur that these complications commonly occur with self–inflicted gunshot wounds, due to placement of the firearm in the submental region, often causing the bullet to traverse the hard palate in most cases.

7. CONCLUSION

The steady increase in urban violence and crime prevalent in the Western Cape has resulted in an increasing incidence of facial gunshot injuries seen at Groote Schuur Hospital, Cape Town. Compounded with these violent crimes, the local firearm ownership laws have been relaxed thus making it easier for civilians to possess firearms thereby further increasing the risk of firearm related injuries. The findings of this study shows that the vast majority of these injuries were due to low velocity handguns with males within their third decade of life being most frequently affected. Socio–political circumstances has resulted in the majority of the sample being of a lower socio–economic status. Gunshot wounds to the face are often dramatic at presentation with their injuries ranging from mild and insignificant to severe life– threatening situations especially when airway compromise is present. Few cases fell into the latter group.

Generally, the low velocity gunshot injuries were predictable with small circumscribed entrance wounds with underlying comminution of teeth and bone and usually with no exit wounds. The cheek area was the most common site of entry. Although care of these injuries must be individualized, a protocol approach helps the clinician rapidly evaluate these patients and plan appropriate treatment. Attention was given to early airway control, although most patients in the present study required no airway management. An initial attempt at orotracheal intubations were done and tracheostomies were carried out electively. Early plain radiographs were taken to determine the trajectories of the missile injury. Rapid neurological assessments were carried out with CT–scans taken were indicated. Angiography was indicated especially when associated neck and vascular injuries were present. Mandibular fractures were more common than maxillary fractures with comminuted displaced fracture patterns being most common. Conservative soft tissue debridement was initiated within twelve hours of presentation. More open reductions with semi–rigid internal fixations using wire transosseous fixations were done than closed reductions. Closed reductions were performed in cases with undisplaced simple and comminuted fractures and were carried out early within twelve hours of presentation. The open reductions were usually delayed for longer than twelve hours.

Autogenous free bone grafting was employed in all cases with continuity defects. Intravenous, intramuscular or oral penicillin and flagyl were the antibiotics of choice in most cases. Cephalosporius were usedÿas an alternative in penicillin allergic patients. Post operative sepsis was reported in 19% of the patients and occurred more often as a late complication together with bony malunion or non–union of the fracture site. This complication rate was relatively high probably due to the increased number of open reductions with possible devitalization of the comminuted bony fragments. The patients with closed reductions generally had a lower rate of sepsis. Therefore closed reductions of comminuted displaced and undisplaced fractures appear to be a safe means of treatment in patients with facial gunshot wounds. The reported rate of ocular injuries were high requiring timeous referral to the ophthalmologists. Associated head injuries were also common requiring early neurosurgical evaluations. This therefore reinforces that a multidisciplinary approach is necessary for successful management of these injuries.

The present study concurs with the findings of most other national and international studies. The management principles eluded to in the present study are similar to those described by most of the recognised international trauma centres. There is an increase in the number of open reductions being performed to treat both displaced and comminuted fractures as shown in the present study. The bony defects, however, are reconstructed secondarily. This differs from the treatment principles described by recent American studies undertaken by Gruss *et al.* (1991) and Manson *et al.* (1985) who apply early difinitive bone and soft tissue reconstruction of gunshot wounds to the face.

8. RECOMMENDATIONS

(a) With the overall increasing numbers in gunshot injuries, recommendations to the law enforcement authorities should be made to tighten firearm licencing laws and regulations.

(b) With the recent increase in crime rates locally, definitive crime prevention and harsher sentencing of firearm related criminal acts should be imposed.

(c) The drastic increase in firearm related mortality in the Cape Town metropole is of dire concern and therefore the Minister of Justice should consider a ban on the ownership of civilian type handguns.

(d) Prospective studies should be undertaken to accurately assess long–term complications. This would further enhance the efficacy of the treatment outcomes.

(e) Our overall treatment protocol for the management of low velocity maxillofacial gunshot injuries are in keeping with international standards. The management of fractures to both the mandible and maxilla should, however, be modified to doing more closed reductions, thereby, reducing hospital stay, overall costing and perhaps post–operative sepsis rates.

9. REFERENCES

[1] Alexander, R.H.; Proctor, H.J. (1993) Advanced trauma life support course for physicians. 17–37.

[2] Banks, P. (1985) Gunshot wounds. Maxillofacial injuries. Edinburgh: Churchill Livingstone, 561–694.

[3] Cohen, M.A. (1984) An analysis of low velocity handgun injuries of the maxillofacial regions (Research report submitted to the Faculty of Dentistry, University of the Witwatersrand).

[4] Denny, A.D.; Sanger, J.R.; Matloub, H.S.; Yousif, N.J. (1992) Self inflicted midline facial wounds: The case for a combined craniofacial and microvascular team approach. *Annals of Plastic Surgery* 29: 564–570.

[5] Dolin, J.; Scalea, T.; Mannor, L.; Sclafani, S.; Trooskin, S. (1992) The management of gunshot wounds to the face. *Journal of Trauma* 33: 508–515.

[6] Ferne, R. (November 1982) Facts About Places. *Reader's Digest*.

[7] Finch, D.R.; Dibbel, D.G. (1979) Immediate reconstruction of gunshot injuries to the face. *Journal of Trauma* 19: 965–968.

[8] Finn, R.A. (1996) Treatment of comminuted mandibular fractures by closed reduction. *Journal of Oral Maxillofacial Surgery* 54: 320–327.

[9] Fleming, A.N.M.; Knottenbelt, J.; Hudson, D. (1993) Maxillofacial gunshot wounds at Groote Schuur Hospital (Paper Presentation at Plastic Surgery Conference).

[10] Fonseca, R.J.; Walker, R.V. (1991) Oral and maxillofacial trauma. W.B. Saunders and Company; Vol.2: 672–694.

[11] Gant, T.D.; Epstein, L.I. (1979) Low velocity gunshot wounds to the maxillofacial complex. *Journal of Trauma* 19: 674–677.

[12] Granger, D. (June 21, 1996) Judge orders probe into lax gun–licensing. *Cape Times*.

[13] Grotepas, F.W.; Booysen, J.T.; Nortjé, C.J.; Farman, A.G. (1990) Treatment of large oro–nasal fistulae using a triper layer technique: 38 cases. *British Journal of Oral and Maxillofacial Surgery* 28: 222–227.

[14] Gruss, J.S.; Antonyshyn, D.; Phillips, J.H. (1991) Early definitive bone and soft–tissue reconstruction of major gunshot wounds of the face. *Plastic and Reconstructive Surgery* 87: 436–450.

[15] Gruss, J.S. (1990) Complex craniomaxillofacial trauma: Evolving concepts in management. A Trauma Units Experience — 1989 Fraser B. Gurd Lecture 30: 377–383.

[16] Gussack, G.S.; Jurkovich, G.J. (1988) Penetrating facial trauma: A management plan. *Southern Medical Journal* 81: 297–302.

[17] Haug, R.H. (1989) Management of low calibre, low velocity gunshot wounds of the maxillofacial region. *Journal of Oral Maxillofacial Surgery* 47: 1192–1196.

[18] Holt, G.R.; Kostohryz Jr. G. (1983) Wound ballistics of gunshot injuries to the head and neck. *Arch Otolaryngol* 109: 313–318.

[19] Joy, E.D. (1973) Early care of maxillofacial missile wounds. *Journal of Oral Surgery* 31: 425–428.

[20] Johnson, A. (February 1996) Tough code of ethics for ministers of parliament (MP's). *Cape Times*.

[21] Kelly, J.F. (1973) Maxillofacial missile wounds: Evaluation of long term results of rehabilitation and reconstruction. *Journal of Oral Surgery* 31: 438–446.

[22] Kihtir, T.; Ivatury, R.R.; Simon, R.; Nassoura, Z.; Lebans, S. (1993) Early management of civilian gunshot wounds to the face. *Journal of Trauma* 35: 569–577.

[23] Lalloo, R. (1997) The maxillofacial unit at Groote Schuur Hospital — who, why and what treatment is provided? 18th African Health Sciences Congress in collaboration with the 15th Epidemiological Society of Southern Africa Conference and the 6th African Regional Conference of the International Epidemiology Association, Cape Town, 14–16 April 1997.

[24] Laskin, D.M. (1994) Giving gun control a shot. *Journal of Oral Maxillofacial Surgery* 52: 1009.

[25] Lerer, L.B.; Matzopoulos, R.G.; Bradshaw, E.D.; Phillips, R. (1995) Violence and injury mortality in the Cape Town metropole. The Cape Town Metropolitan Non–Natural Mortality Study Group and the Health Consulting Office, Health Technology Research Group. *Medical Research Council* 1–53.

[26] Lerer, L.B.; Matzopoulos, R.G.; Phillips, R. (1997) Violence and injury mortality in the Cape Town metropole. *South African Medical Journal* 87: 298–301.

[27] Lerer, L.B. (1997) Responding to violence in South Africa — from public thetoric to public health. 87: 283–285.

[28] Lownie, M.A.; Lownie, J.F. (1996) Facial fracture trends over a fourteen year period. Paper presented at the Triangular Maxillofacial and Oral Surgeons Congress, Cape Town, 6–9 March 1996.

[29] Manson, P.N.; Crawley, W.A.; Yaremchuk, M.J.; Rochman, G.M.; Hoopes, J.E.; French, J.H. (1985) Midface Fractures: Advantages of immediate extended open reduction and bone grafting. *Plastic and Reconstructive Surgery* 76: 1–12.

[30] May, M.; Lutchavaree, A.; Chadaratana, P.; West, J. (1973) Mandibular fractures from civilian gunshot wounds: A study of 20 cases. *The Laryngoscope*: 969–973.

[31] Nelson, C.L.; Puskarich, C.L.; Marks, A. (1987) Gunshot wounds. Incidence, costs and concepts of prevention. *Clinical Orthopaedics and Related Research* 222: 114–121.

[32] Neupert III E.A.; Boyd, S.B. (1991) Retrospective analysis of low velocity gunshot wounds to the mandible. *Oral Surgery; Oral Medicine; Oral Pathology* 72: 383–387.

[33] Pinnock, D. (1984) The Brotherhoods: Street gangs and state control in Cape Town. David Phillips: 1–18.

[34] Rogers, B.O.; Rhode, M.G. (1995) The first civil war photographs of soldiers with facial wounds. *Aesthetic Plastic Surgery* 19: 269–283.

[35] Rowe, N.L.; Williams, J.L. (1985) Maxillofacial Injuries. Vol.2: 560–694.

[36] Saletta, J.P.; Louwe, R.J.; Lim, J.T. (1976) Penetrating trauma to the neck. *Journal of Trauma* 25: 579.

[37] Sellier, K.G.; Kneubuehl, B.P. (1994) Wound ballistics and the scientific background.

[38] Shuck, L.W.; Orgel, M.G.; Vogel, A.V. (1980) Self inflicted gunshot wounds to the face: A review of 18 cases. *The Journal of Trauma* 20: 370–377.

[39] Smith, B.R.; Teenier, T.J. (1996) Treatment of comminuted mandibular fractures by open reduction and rigid internal fixation. *Journal of Oral Maxillofacial Surgery* 54: 328–331.

[40] Swan, K.G.; Swan, R.C. (1980) Gunshot wounds, pathophysiology and management. PSG Publishing Company, Inc.: 1–13.

[41] Swan, K.G.; Swan, R.C. (1991) Principles of ballistics applicable to the treatment of gunshot wounds. *Surgical Clinics of North America* 71: 221–239.

[42] Thorne, C.H. (1992) Gunshot wounds to the face. Current Concepts. *Clinics in Plastic Surgery* 19: 233–244.

[43] Tsakiris, P.; Lownie, M.A.; Cleaton–Jones, P.E. (1996) A retrospective study of maxillofacial gunshot injuries. Paper presented at the Triangular Maxillofacial and Oral Surgeons Congress, Cape Town, 6–9 March 1996.

[44] Vásconez, H.C.; Shockley, M.E.; Luce, E.A. (1996) High energy gunshot wounds to the face. *Annals of Plastic Surgery* 36: 18–25.

[45] Veller, M.; Green, H. (1984) Gunshot injuries seen at Johannesburg Hospital during 1982. *South African Medical Journal* 66: 24–26.

[46] Williams, C.N.; Cohen, M.; Schultz, R.C. (1988) Intermediate and long term management of gunshot wounds to the lower face. *Plastic and Reconstructive Surgery* 82: 433–439.

[47] Yao, S.T.; Vanecko, R.M.; Corley, R.D.; Stuteuille, O.H.; Shoemaker, W.C. (1972) *Journal of Trauma* 12: 523–528.

[48] Zide, M.F.; Epker, B.N. (1979) Short range gunshot wounds to the face. *Journal of Oral Surgery* 37: 319–329.

Appendix I
(Trauma Unit Record)

(H313011 - 11/92 - 200 000) A.P.,C.T PD 261

PLEASE RETURN TOP COPY TO TRAUMA UNIT C14 IF FOUND IN NOTES

GROOTE SCHUUR HOSPITAL

TRAUMA UNIT RECORD

D 0146606

Registration time [ ][ ][ ][ ] H H M M

STICKY LABEL — COPY MUST ALSO BE LABELED

Initials (1–5) [ ][ ][ ][ ][ ] Surname (6–29) [ ]

First name (30–41) [ ] Folder no. (42–49) [ ] Date of birth (50–57) [ ] Race/Sex (58) [ ]

Address [ ] Postal code [ ]

Date (59–64) [ ] Time seen (nearest hr.–24-hr. clock) (65) [ ] Hours since injury (67) [ ] Duration in acc. unit–hrs. (69–71) [ ]

(Race/Sex)
(1 = W-M 3 = C-M 7 = B-M)
(2 = W-F 4 = C-F 8 = B-F)

ADMISSION

(MARK ONE CODE WITH A CROSS)

72
- 1 Not admitted
- 2 Admitted to trauma unit
- 3 Admitted directly to other ward, theatre or I.C.U.

DISPOSAL FROM TRAUMA UNIT (MARK ONE CODE WITH A CROSS)

73-74
- 01 Absconded
- 02 Home/G.P.
- 03 Day hospital
- 04 Other hospital
- 05 Out patients dept.
- 06 Police
- 07 Died

TRANSFERRED TO:
- 08 Orthopaedic ward
- 09 Neurosur. ward/I.C.U.
- 10 Thoracic sur. ward
- 11 General sur. ward
- 12 Plastic sur. ward
- 13 Ophthalm. ward
- 14 Urology ward
- 15 E.N.T. ward
- 16 Respir. I.C.U.
- 17 Other ward
- 18 Surgical I.C.U.
- 19 Operating Theatre

(MARK EACH OF THE CODES WITH A CROSS)

UN-CONSCIOUS (75)	SHOCK (76)	RESUSCITATION (77)
1 No	1 No	1 None
2 Yes	2 Yes	2 Simple
		3 Complex

ANAESTHETIC GIVEN (78)	INTENTIONAL SELF-INFLICTED (79)	TRIAGE CODE
1 None	1 No	1 Red
2 Local/Regional	2 Possibly	2 Yellow
3 General	3 Yes	3 Green

CAUSE (MARK ONE CODE WITH A CROSS)

TRANSPORT
80-81
- 01 Motor cycle
- 02 MVA — pedestrian
- 03 MVA — passenger
- 04 MVA — driver
- 05 Cycle
- 06 Train
- 07 Other transport (e.g. boat, horse)

ASSAULT
- 10 Blunt
- 11 Sharp
- 12 Rape
- 13 Human bite
- 14 Other assault
- 20 Fire arm
- 21 Machinery

BURN/EXPLOSION
- 30 Flame
- 31 Fluid
- 32 Electrical
- 33 Chemical
- 34 Other: Burn/expl.
- 40 Fall
- 41 Struck by/against or caught between objects

- 42 Sharp instrument
- 43 Immersion

BITES
- 50 Dog
- 51 Other mammal
- 52 Other (e.g. fish)
- 60 Other cause
- 70 Unknown

PLACE OF OCCURRENCE

(MARK ONE CODE WITH A CROSS)

AT SPORT
82
- 1 Rugby
- 2 Soccer
- 3 Mountaineering
- 4 Horse riding
- 5 Other sport
- 6 At home
- 7 At work
- 8 On road/pavement
- 9 Other
- 0 Unknown

CODES FOR ANATOMY, PATHOLOGY, ABBR. INJURY SCORE AND TREATMENT (One set of codes per injury, Maximum 4)

	ANAT.	PATH.	AIS.	TRT.
1.	83 [ ][ ]	[ ][ ]	[ ]	88 [ ]
2.	89 [ ][ ]	[ ][ ]	[ ]	94 [ ]
3.	95 [ ][ ]	[ ][ ]	[ ]	100 [ ]
4.	101 [ ][ ]	[ ][ ]	[ ]	106 [ ]

ANATOMY
- 01 No injury
- 02 Scalp
- 03 Skull
- 04 Brain –closed
- 05 Brain –open
- 06 Eyes(s)
- 07 Nose
- 08 Maxilla
- 09 Mouth/orophar.
- 10 Mandible
- 11 Face –other
- 12 Neck
- 13 Shoulder girdle
- 14 Shoulder joint
- 15 Upper arm
- 16 Elbow joint
- 17 Forearm
- 18 Wrist
- 19 Hand
- 20 Nerve/plexus
- 21 Thorax cage
- 22 Thorax respir.
- 23 Thorax C.V.S.
- 24 Abdominal wall
- 25 Abdominal viscus
- 26 Kidney/ureter
- 27 Bladder/urethra
- 28 Pelvis/Buttock
- 29 Perineum
- 30 Vertebral column
- 31 Spinal cord
- 32 Hip/femoral neck
- 33 Femur –shaft
- 34 Knee region
- 35 Tibula/Fibula –shaft
- 36 Ankle region
- 37 Foot
- 38 No area injured

PATHOLOGY
- 01 None
- 02 Abrasions
- 03 Closed tissue
- 04 Laceration –superfic.
- 05 Laceration –complic.
- 06 Avulsion/amputation
- 07 Burns
- 08 Vascular injury
- 09 Nerve injury
- 10 Muscle/tendon injury
- 11 Sprain/ligament rupture
- 12 Dislocation
- 13 Joint injury –closed
- 14 Joint injury –open
- 15 Other joint injury
- 16 Fracture –pathological
- 17 Fracture –closed
- 18 Fracture –open
- 19 Fracture –dislocation
- 20 Foreign body
- 21 Pneumothorax
- 22 Haemothorax
- 23 Haemopneumothorax
- 24 Fat embolism
- 25 Other injury
- 26 No pathology
- 27 Hypothermia
- 28 Medical Problem

ABBR. INJURY SCORE (AIS)
- 1 – Minor
- 2 – Moderate
- 3 – Severe/Extensive
- 4 – Possibly mortal
- 5 – Probably mortal
- 6 – Definitely mortal

TREATMENT
- 1 – Advice/Medical only
- 2 – Dressing/simple p.o.p.
- 3 – Sutures
- 4 – Manipulation
- 5 – Amputation
- 6 – Open operation
- 7 – Drainage
- 8 – Skin graft
- 9 – Other

DOCTOR'S NAME (PRINT) DOCTOR'S SIGNATURE

(H313011 - 11/92 - 200 000) A.P.,C.T PD 261

GROOTE SCHUUR HOSPITAL

TRAUMA UNIT RECORD

D 0146606

Registration time H H M M

STICKY LABEL — COPY MUST ALSO BE LABELED

Initials (1–5) Surname (6–29)

First name (30–41) Folder no. (42–49) Date of birth (50–57) Race/Sex (58)

Address Postal code

Date (59–64) Time seen (nearest hr.–24-hr. clock) (65) Hours since injury (67) Duration in acc. unit–hrs. (69–71)

(Race/Sex)
(1 = W-M 3 = C-M 7 = B-M)
(2 = W-F 4 = C-F 8 = B-F)

ADMISSION (MARK ONE CODE WITH A CROSS)

72
1 Not admitted
2 Admitted to trauma unit
3 Admitted directly to other ward, theatre or I.C.U.

DISPOSAL FROM TRAUMA UNIT (MARK ONE CODE WITH A CROSS)

73-74

01 Absconded
02 Home/G.P.
03 Day hospital
04 Other hospital
05 Out patients dept.
06 Police
07 Died

TRANSFERRED TO:

08 Orthopaedic ward
09 Neurosur. ward/I.C.U.
10 Thoracic sur. ward
11 General sur. ward
12 Plastic sur. ward
13 Ophthalm. ward
14 Urology ward
15 E.N.T. ward
16 Respir. I.C.U.
17 Other ward
18 Surgical I.C.U.
19 Operating Theatre

(MARK EACH OF THE CODES WITH A CROSS)

UN-CONSCIOUS (75)	SHOCK (76)	RESUSCITATION (77)
1 No	1 No	1 None
2 Yes	2 Yes	2 Simple
		3 Complex

ANAESTHETIC GIVEN (78)	INTENTIONAL SELF-INFLICTED (79)	TRIAGE CODE
1 None	1 No	1 Red
2 Local/ Regional	2 Possibly	2 Yellow
3 General	3 Yes	3 Green

CAUSE (MARK ONE CODE WITH A CROSS)

80-81

TRANSPORT
01 Motor cycle
02 MVA — pedestrian
03 MVA — passenger
04 MVA — driver
05 Cycle
06 Train
07 Other transport (e.g. boat, horse)

ASSAULT
10 Blunt
11 Sharp
12 Rape
13 Human bite
14 Other assault
20 Fire arm
21 Machinery

BURN/EXPLOSION
30 Flame
31 Fluid
32 Electrical
33 Chemical
34 Other: Burn/expl.
40 Fall
41 Struck by/against or caught between objects

42 Sharp instrument
43 Immersion

BITES
50 Dog
51 Other mammal
52 Other (e.g. fish)
60 Other cause
70 Unknown

PLACE OF OCCURRENCE

(MARK ONE CODE WITH A CROSS)

AT SPORT

82

1 Rugby
2 Soccer
3 Mountaineering
4 Horse riding
5 Other sport
6 At home
7 At work
8 On road/pavement
9 Other
0 Unknown

CODES FOR ANATOMY, PATHOLOGY, ABBR. INJURY SCORE AND TREATMENT (One set of codes per injury, Maximum 4)

	ANAT.	PATH.	AIS.	TRT.
1.	83			88
2.	89			94
3.	95			100
4.	101			106

ANATOMY

01	No injury	13	Shoulder girdle	26	Kidney/ureter
02	Scalp	14	Shoulder joint	27	Bladder/urethra
03	Skull	15	Upper arm	28	Pelvis/Buttock
04	Brain –closed	16	Elbow joint	29	Perineum
05	Brain –open	17	Forearm	30	Vertebral column
06	Eyes(s)	18	Wrist	31	Spinal cord
07	Nose	19	Hand	32	Hip/femoral neck
08	Maxilla	20	Nerve/plexus	33	Femur –shaft
09	Mouth/orophar.	21	Thorax cage	34	Knee region
10	Mandible	22	Thorax respir.	35	Tibula/Fibula –shaft
11	Face –other	23	Thorax C.V.S.	36	Ankle region
12	Neck	24	Abdominal wall	37	Foot
		25	Abdominal viscus	38	No area injured

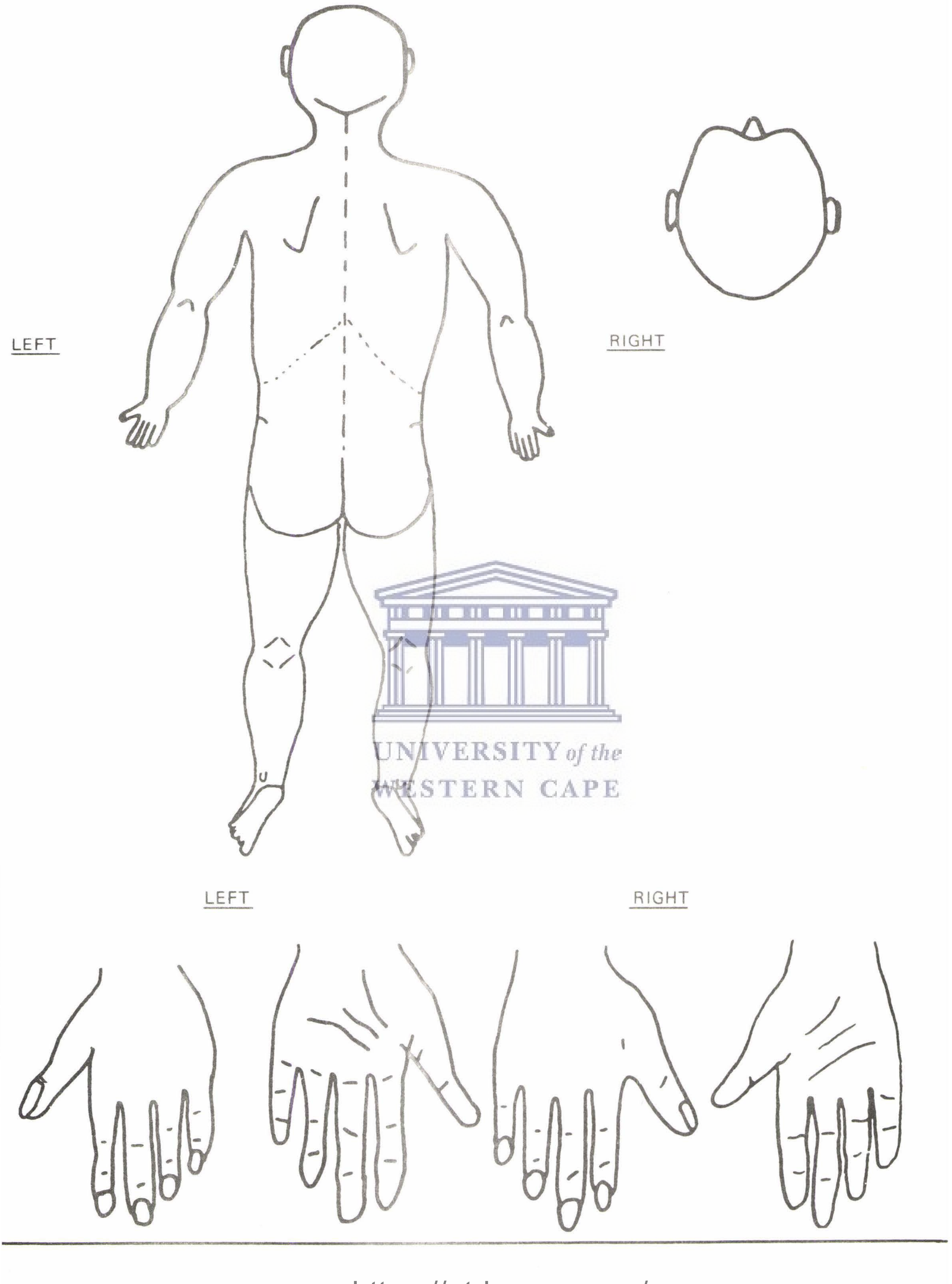
PATHOLOGY

01	None	14	Joint injury –open
02	Abrasions	15	Other joint injury
03	Closed tissue	16	Fracture –pathological
04	Laceration –superfic.	17	Fracture –closed
05	Laceration –complic.	18	Fracture –open
06	Avulsion/amputation	19	Fracture –dislocation
07	Burns	20	Foreign body
08	Vascular injury	21	Pneumothorax
09	Nerve injury	22	Haemothorax
10	Muscle/tendon injury	23	Haemopneumothorax
11	Sprain/ligament rupture	24	Fat embolism
12	Dislocation	25	Other injury
13	Joint injury –closed	26	No pathology
		27	Hypothermia
		28	Medical Problem

ABBR. INJURY SCORE (AIS)
1 – Minor
2 – Moderate
3 – Severe/Extensive
4 – Possibly mortal
5 – Probably mortal
6 – Definitely mortal

TREATMENT
1 – Advice/Medical only
2 – Dressing/simple p.o.p.
3 – Sutures
4 – Manipulation
5 – Amputation
6 – Open operation
7 – Drainage
8 – Skin graft
9 – Other

DOCTOR'S NAME (PRINT) DOCTOR'S SIGNATURE


LEFT
RIGHT
LEFT
RIGHT

Appendix II
(Department of Medical Informatics Form)

T.P. 2040 (Revised - 02/96)

GROOTE SCHUUR HOSPITAL
DEPARTMENT OF MEDICAL INFORMATICS

Request for analysis of computer records

COMPUTER PROJECT : ....DATE : ....

REQUESTED BY : ....EXT : ....

DEPARTMENT : ....BLEEP: ....

PURPOSE FOR WHICH INFORMATION IS REQUIRED : ....

....

PUBLICATION PROPOSED : YES/NO AUTHORS : ....

SPECIFICATION : ....

....

....

....

....

....

....

....

....

....

....

....

APPROVED BY: ....(HEAD OF YOUR DEPARTMENT)

APPROVED BY: ....(DATA CUSTODIAN)

SEND TO : CHIEF PROGRAMMER, DEPT OF MEDICAL INFORMATICS, M51, O.M.B

FOR DEPARTMENTAL USE ONLY :

DATE REQUEST RECEIVED	:	DATE APPROVAL RECEIVED	: ....
PROGRAMMER DATE STARTED	:	DATE COMPLETED	: ....
PROGRAMMER	:	TIME SPENT	: ....
BSPI : LIST	:	TABLES	: ....
AMENDED PROGRAMS	:	NEW PROGRAMS	: ....
JOB NAME	:	COST	: ....

PROGRAMMER COMMENTS : ....

....

....

Appendix III
(Proforma)

PROFORMA

GUNSHOT INJURIES TO THE MAXILLOFACIAL REGION

YEAR 19________

[01] CASE NUMBER ☐☐☐

[02] FOLDER NUMBER ☐☐☐☐☐☐☐☐

[03] AGE ☐☐

[04] SEX ☐

[05] ADDRESS (SUBURB) ____________________

[06] INCOME STATUS ☐☐

[07] TOTAL HOSPITALIZATION days ☐☐☐

[08] VELOCITY OF BULLET............a) High ☐
b) Low ☐
c) Unknown ☐

[09] RANGE.........................a) Close ☐
b) Far ☐
c) Unknown ☐

[10] MECHANISM OF INJURY...........a) Accidentally self-inflicted ☐
b) Intentionally self-inflicted ☐
c) Accidentally inflicted by another ☐
d) Intentionally inflicted by another ☐
e) Unknown ☐

[11] ANATOMICAL REGION.............a) Eyes ☐
b) Nose ☐
c) Maxilla ☐
d) Mouth/Oropharynx ☐
e) Mandible ☐
f) Face/Other ☐
g) Ear ☐

[12] SITE OF ENTRANCE WOUND........a) Cheek ☐
b) Mouth area ☐
c) Chin area ☐
d) Eye area ☐
e) Nose area ☐
f) Ear area ☐
g) Neck ☐
h) Temple ☐
i) Unknown ☐
j) None ☐

[13] SITE OF EXIT WOUND............a) Cheek ☐
b) Neck ☐
c) Mouth ☐
d) Nose ☐

e) Lip
f) Forehead
g) Unknown
h) None
i) Eyes
j) Head Region

[14] HARD TISSUE INJURY............a) Simple
b) Comminuted
c) Displaced
d) Undisplaced
e) Unknown
f) None

[15] MANDIBULAR FRACTURE SITES.....a) Dentoalveolar
b) Teeth
c) Body
d) Symphyseal
e) Parasymphyseal
f) Ramus
g) Angle
h) Condyle
i) Subcondyle
j) Coronoid process
k) Combination (specify) ______________________
l) None

[16] MAXILLARY FRACTURE SITES......a) Dentoalveolar
b) Teeth
c) Palate
d) Middle third
e) Zygoma
f) Sinuses
g) Nose
h) Orbit
i) Combination (specify) ______________________
j) None

[17] AIRWAY........................a) Controlled Intubation
* Oral
* Nasal
b) Cricothyroidotomy
c) Tracheostomy
d) None

[18] ASSOCIATED INJURY.............a) Head
b) Neck
c) Thorax

d) Abdomen
e) Limbs
f) None

[19] SPECIAL INVESTIGATIONS........a) Conventional X-rays
b) Angiogram
c) CT Scan
d) Other (specify) ______________________________
e) None

SURGICAL TREATMENT

[20] HARD TISSUE...................a) Debridement (a) Early
(b) Late
(c) None
b) Reduction (a) Open
(b) Closed
(c) None
c) Fixation (a) Plating
(b) Wiring
(c) Combination
(d) External Fixation
(e) Grafting
(f) Other

[21] SOFT TISSUE...................a) Debridement (a) Early
(b) Late
(c) None
b) Flaps (a) Local
(b) Distant
(c) None

[22] TIMING OF TREATMENT OF FRACTURES (a) Immediate (to 12 hrs)
(b) Delayed (12 hrs & later)
(c) None

[23] ANTIBIOTICS...................a) Route (a) Oral
(b) Intravenous
(c) Intramuscular
(d) Combination
(e) None
b) Period (a) 2-3 days
(b) Longer than 3 days
(specify) ______________________
(c) Stat
(d) None
c) Type (a) Penicillins
(b) Flagyl

(c) Aminoglycosides ☐

(d) Cephalosporins ☐

(e) Other (specify) ☐

____

[24] ONSET OF COMPLICATIONS........a) Early (days to 1 week) ☐

b) Late (1 month or later) ☐

c) None ☐

[25] TYPES OF COMPLICATIONS........a) Cosmetic ☐

b) Sepsis ☐

c) Dysfunction ☐

d) Limitation of mouth opening ☐

e) Blindness ☐

f) Neurological ☐

g) Other (specify) ____________________________ ☐

____

h) None ☐

Appendix IV
(Letter to Chief Medical Superintendent)

Department of Maxillofacial and Oral Surgery
Faculty of Dentistry & WHO Oral Health Collaboration Centre
UNIVERSITY OF THE WESTERN CAPE
Private Bag X08, Mitchells Plain 7785
CAPE TOWN

Chief Medical Superintendent
Groote Schuur Hospital

Dear Sir/Madam

RE: <u>PERMISSION FOR THE USE OF CLINICAL RECORDS</u>:

As a registrar in the Department of Maxillofacial and Oral Surgery, I am required to submit a dissertation in partial fulfilment of the degree MChD at the Faculty of Dentistry and WHO Collaboration Centre, University of the Western Cape.

The topic of my thesis is "A retrospective analysis of gunshot injuries to the maxillofacial region treated at Groote Schuur Hospital between the period 1980 to 1995."

Your permission is hereby requested for the use of the relevant clinical records. Strict patient confidentiality will be adhered to.

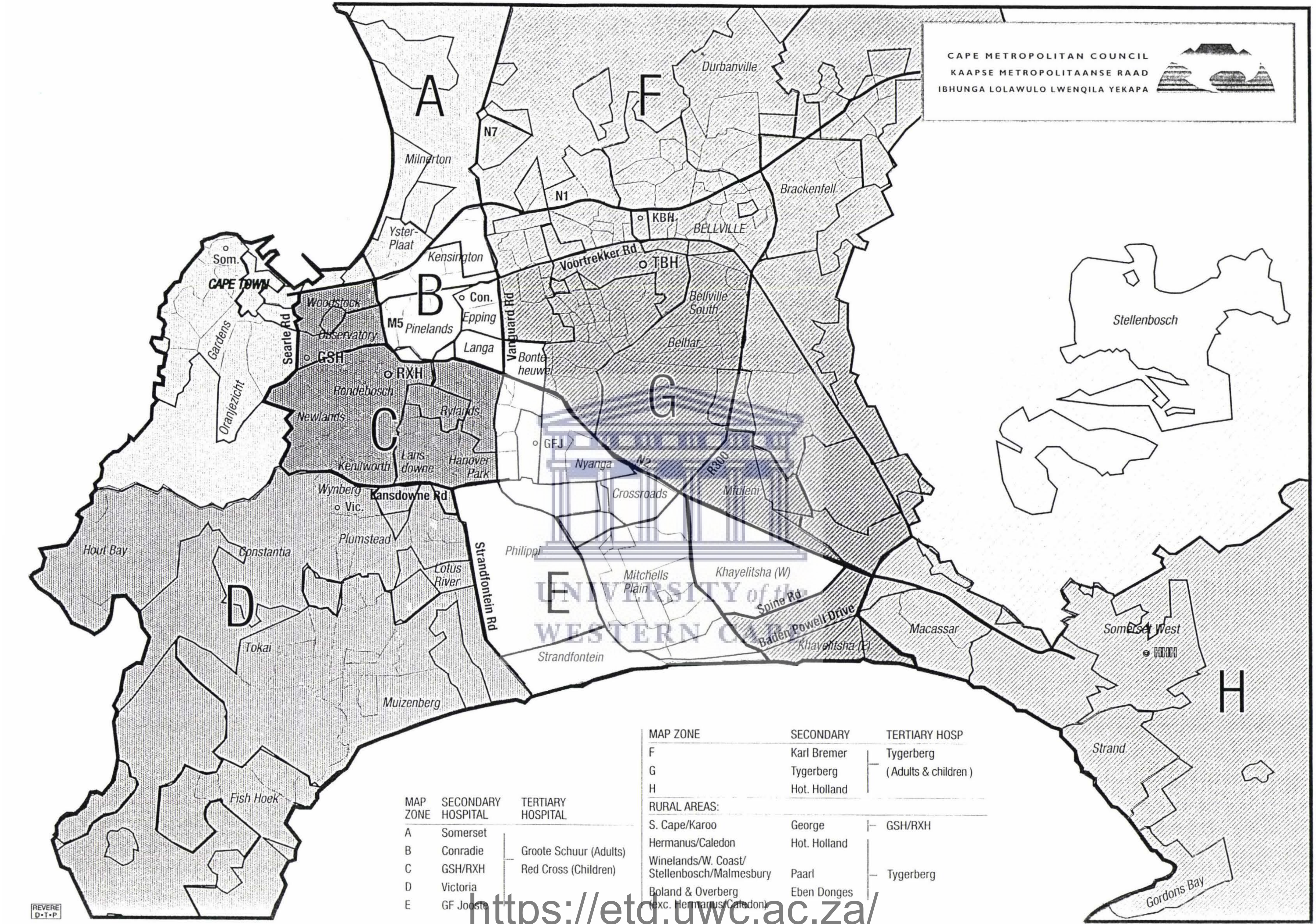
Thanking you in anticipation.

Yours sincerely

Dr. A.H. Kassan

Prof. G. Kariem/Dr. R. Lalloo
(Supervisors)

Appendix V
(Map of Residential Areas of Cape Town)


CAPE METROPOLITAN COUNCIL
KAAPSE METROPOLITAANSE RAAD
IBHUNGA LOLAWULO LWENQILA YEKAPA
A
B
C
D
E
F
G
H
Milnerton
Yster-Plaat
Kensington
Som.
CAPE TOWN
Woodstock
Observatory
GSH
Gardens
Oranjezicht
Searle Rd
M5
Pinelands
Con.
Epping
Langa
Vanguard Rd
Bonteheuwel
RXH
Rondebosch
Newlands
Rylands
Lansdowne
Kenilworth
Hanover Park
Wynberg
Lansdowne Rd
Vic.
Plumstead
Constantia
Hout Bay
Lotus River
Strandfontein Rd
Tokai
Muizenberg
Fish Hoek
N7
N1
KBH
BELLVILLE
Voortrekker Rd
TBH
Bellville South
Belhar
Durbanville
Brackenfell
GFJ
Nyanga
N2
R300
Mfuleni
Crossroads
Philippi
Mitchells Plain
Khayelitsha (W)
Spine Rd
Baden Powell Drive
Khayelitsha (E)
Strandfontein
Macassar
Somerset West
HHH
Stellenbosch
Strand
Gordons Bay
REVERE D•T•P
MAP ZONE | SECONDARY HOSPITAL | TERTIARY HOSPITAL
A | Somerset |
B | Conradie | Groote Schuur (Adults)
C | GSH/RXH | Red Cross (Children)
D | Victoria |
E | GF Jooste |
MAP ZONE | SECONDARY | TERTIARY HOSP
F | Karl Bremer | Tygerberg
G | Tygerberg | (Adults & children)
H | Hot. Holland |
RURAL AREAS:
S. Cape/Karoo | George | GSH/RXH
Hermanus/Caledon | Hot. Holland |
Winelands/W. Coast/ Stellenbosch/Malmesbury | Paarl | Tygerberg
Boland & Overberg (exc. Hermanus/Caledon) | Eben Donges |