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Contents

Maxillo-Facial Injuries in Aircraft Accidents

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Introduction

Head injury is one of the commonest sequelae of all types of accident and, either alone, or in combination with injuries elsewhere, it is a potent cause of mortality and morbidity. Inevitably therefore, this subject has stimulated considerable interest amongst research workers in all aspects of accident-injury research. Despite this interest and the large amount of research which it has spawned there are many gaps in our knowledge. This is especially so where maxillo-facial injuries are concerned, for most of the work which has been done, has been directed at attempts to resolve the controversies surrounding the pathogenesis of intracranial injury.

This paper looks at the frequency of maxillo-facial injuries in the victims of fatal aircraft accidents and discusses them in the context of the known biodynamic principles of injury causation.

Method

Post-mortem reports compiled by various pathologists, whilst investigating all types of fatal civil and military aircraft accidents, were examined and the information concerning facial injuries was abstracted. The gross details of the series are given in Table I.

Table 1. Fate of the Occupants

	Killed		*Injured*		*Uninjured*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Aircrew	768	87,5	60	6,8	50	5,7	878	100
Cabin crew	53	79,1	9	13,4	5	7,5	67	100
Passengers	1 105	81,4	111	8,2	142	10,5	1 358	100,1

Each of the injuries was scored on a scale of increasing severity ranging from no injury (0) through mild (1), moderate (2), severe (3) to fatal (4). Total dismemberment of the body was listed separately.

Where there were a number of injuries in one area, the region was scored and not the injury. This obviated the possibility of a fatal score being given for 4 abrasions on the cheek. Mild injuries are lesions such as small bruises and lacerations which do not require much energy to cause them, do not pose a threat-to-life and heal without leaving any

functional impairment. Grade 2 injuries are more extensive, may be simple undisplaced fractures, and whilst complete recovery is expected they do require treatment if functional impairment and scarring is either to be avoided or minimised. Severe or grade 3 injuries are extensive, considerable force being needed to cause them, they pose a threat-to-life, early treatment is necessary and there may well be long term functional impairment. Compound fractures in which contamination is almost certainly a feature, widespread lacerations with associated damage to subjacent tissues and tissue loss are included in this category. Fatal injuries are self explanatory.

The information thus collected was filed on proformae and subsequently statistically analysed by computer.

Results

The statistics generated are given in Tables 2 and 3. These show the gross injuries recorded according to the degree of damage of the aeroplane. The tables presented are an abbreviation of the total available statistics. They have been chosen so as to show the principle features of the reported pattern of injuries. Those involving the eye and the ear are not included. In each case the total number of reported injuries was less than 1%.

Discussion

The fundamental concepts underlying the pathogenesis of facial injuries have been discussed at length in the literature.[1–3] In summary it may be stated that the body is composed of a wide range of tissues, each of which exhibits different physical and chemical characteristics. Thus when a force is applied to any part it will react in accordance with these features. Though the nature of this reaction is a function of the part impacted, and the force, it is subjected to certain factors common to all tissues. Thus impact forces set up 'shock waves' within the tissues which behave like vibrations and are transmitted throughout the local area of impact and beyond, the extent of the transmission being dependent upon the intensity of the force and the characteristics of the part involved.

Head injury is a very controversial topic, largely because of the polarisation of opinions, but facial injury is not nearly so difficult to explain. However, it must be remembered that head and facial injury are usually closely related and that the fact that an individual does sustain damage to the face, usually implies some degree of head injury, although the reverse does not necessarily hold. Nevertheless there is general agreement amongst workers regarding methods of causation of facial injuries.

There is a good correlation between structure and function, which plays a role in the natural and unnatural stresses that can be withstood by the facial skeleton.

The mandible is composed of an outer layer of compact bone, surrounding a well developed cancellous interior. Both are of variable

Table 2. Incidence of various grades of facial injury according to side — Halton Series

		Severity of injury													
		Unspecified		*0*		*1*		*2*		*3*		*4*		*Total disintegration*	
Bodily region		*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Face	L	209	(9,5)	403	(18,4)	242	(11,0)	150	(6,8)	161	(7,3)	247	(7,3)	779	(35,6)
	R	209	(9,5)	427	(19,5)	222	(10,1)	147	(6,7)	159	(7,3)	248	(11,3)	779	(35,6)
Mouth	L	209	(9,5)	1 164	(53,1)	14	(0,6)	10	(0,5)	9	(0,4)	5	(0,2)	780	(35,6)
	R	209	(9,5)	1 166	(53,2)	13	(0,6)	8	(0,4)	10	(0,5)	5	(0,2)	780	(35,6)
Malar	L	209	(9,5)	999	(45,6)	1	(0,0)	72	(3,3)	123	(5,6)	8	(0,4)	779	(35,6)
	R	209	(9,5)	995	(45,6)	0	(0,0)	76	(3,5)	124	(5,7)	8	(0,4)	779	(35,6)
Mandible	L	209	(9,5)	837	(38,2)	2	(0,1)	141	(6,4)	188	(8,6)	35	(1,6)	779	(35,6)
	R	209	(9,5)	832	(38,0)	3	(0,1)	139	(6,3)	195	(8,9)	34	(1,6)	779	(35,6)
Maxilla	L	209	(9,5)	800	(36,5)	0	(0,0)	97	(4,4)	211	(9,6)	95	(4,3)	779	(35,6)
	R	209	(9,5)	789	(36,0)	1	(0,0)	100	(4,6)	213	(9,7)	100	(4,6)	779	(35,6)
Nose	L	209	(9,5)	895	(40,8)	5	(0,2)	133	(6,1)	162	(7,4)	8	(0,4)	779	(35,6)
	R	209	(9,5)	892	(40,7)	5	(0,2)	139	(6,3)	159	(7,3)	8	(0,4)	779	(35,6)
Teeth	L	209	(9,5)	1 174	(53,6)	6	(0,3)	13	(0,6)	5	(0,2)	5	(0,2)	779	(35,6)
	R	209	(9,5)	1 175	(53,6)	4	(0,2)	16	(0,7)	3	(0,1)	5	(0,2)	779	(35,6)

Table 3. Rates of injury grades 1 - 4 in the various facial regions

Region	*Slight*	*Substantial*	*Total wreck*	*Ratio substantial : total wreck*
Maxilla	—	41	708	1:17,27
Mandible	—	35	646	1:18,46
Zygoma	—	19	367	1:19,05
Mouth	—	6	64	1:10,67
Nose	—	19	269	1:14,16

thickness and are designed to accept the forces of mastication, which may be considerable. They do this by absorption and dissemination in the same way that other areas of the body cope with stresses and strains. Some of the mandibular forces are transmitted via the tempero-mandibular joint to the base of the skull. The thickness of the bone and the shape of the mandible are materially altered by the presence or absence of the dentition and age.

One of the most extensive surveys of facial fractures is that of Killey and Rowe.[4] This showed that the mandibular alveolus is the weakest part of this bone and that the edentulous mandible is weaker than that containing teeth. Once the teeth have been removed the bone resorbs because the pattern of stresses and strains which it is designed to withstand is altered and most of its bulk may be lost. In the elderly edentulous person only a thin strip of bone may remain and it is not unknown for this to fracture during normal mastication.

The maxilla is an excellent example of functional design. Whilst its individual parts consist of delicate latticeworks, the whole is capable of absorbing and evenly distributing masticatory forces across the base of the skull. The only really solid parts of the upper jaw are its lateral and posterior attachments via the zygomatico-maxillary sutures and the junction of the palatine bone and the pterygoid process of the sphenoid.

As the alveolus has to support the teeth it needs to be strong, and indeed it is capable of regularly withstanding without detriment, quite intense forces often in excess of 200 lbs. per square inch during normal chewing. There is one other feature of the maxilla which makes it especially interesting and that is its angle of attachment to the base of the skull. It is set at an angle of about 45 degrees to the horizontal and thus designed to resist vertically directed forces. Antero-posteriorly directed forces will tend to displace it backwards down the inclined plane of the base of the skull.

Mandibular fractures may be restricted to the alveolus or they may involve the base of the skull. They may be unilateral, bilateral or multiple. Direct violence to one side of the mandible can cause a fracture on the opposite side by the formation of secondary lines of stress. These cause divergence of the mandibular angle thereby compressing the lateral cortical plate medially. This is especially common in the third molar region. As the lingual plate is thin the mandible is pushed backwards so that the fracture line may extend behind or around the tooth socket.

Symphyseal fractures are produced either by direct violence or by lateral compression. The presence of condylar and symphyseal fractures together indicates that direct violence was used. Here the fracture of the condyle is acting as a safety valve. Force applied directly to the chin is transmitted backwards along the rami, to the condyles and thence to the base of the skull. If the condylar neck were not comparatively weaker than the remainder it would transmit all of the force through to, and thus conceivably damaging the base of the skull and the brain.

Fractures at the symphysis caused by direct force occur because the lingual plate is stretched and the outer plate is compressed. Lateral compressive impacts force the angles medially and in so doing create tension around the genial tubercles.

As the temperomandibular joint is protected by the robust zygomatic arch, fractures here are rarely a result of direct violence.

Fractures of the maxillary middle third are potentially much more serious because of their tendency to involve the airway and the eyes. They were first classified by Le Fort in 1901. He subjected cadavers to a series of controlled blows, and by doing so, identified three planes of potential weakness in the maxilla (Fig. 1).

Although injuries to the nasal bones alone can occur, they usually involve the frontal process of the maxilla and they may extend to the lacrimal bones and the orbital laminae of the ethmoid. The septal cartilage may be avulsed and if the injury is severe the remainder of the ethmoid may be involved. In lateral impacts the frontal process of the maxilla and the nasal bone on the affected side may be detached. This usually occurs at the fronto-maxillary and fronto-nasal sutures. In frontal impacts there is backward displacement and splaying outwards of the bones. Involvement of the paranasal sinuses in fractures usually occurs in Le Fort types II and III, and is associated with a 25% incidence of C.S.F. rhinorrhoea.

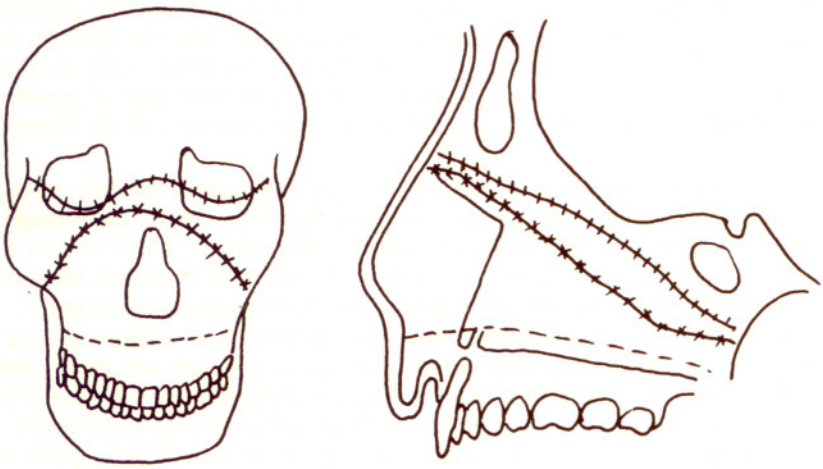

Fig. 1. Lines of potential weakness in the Maxilla — after LE FORT.

The zygoma is a thick, dense structure which is designed to transmit masticatory forces to the cranial base and is adapted to withstand considerable force from below via the broad maxillary suture. Blows on the prominence are unlikely to shatter the bone but will transmit the force either medially into the maxilla or up into the orbit.

The extremely thin and delicate nature of the bone constituting the central portion of the orbital floor is of particular interest in relation to fractures of the zygomatico-maxillary complex. A simple linear fracture is of little importance but a comminuted depressed type of fracture will lead to serious complications unless it is recognised and treated appropriately. This type of injury will, of course, be sustained following a penetrating wound but it is less well appreciated that fragmentation of the orbital floor can occur without fracture of the orbital rim or zygomatic bone. This state follows a blow on the eyeball by, for example, a tennis ball so that the globe is forced posteriorly and acts like a plunger upon the surrounding structures and in particular, the relatively incompressible peri-orbital fat. The dense, strong and laterally angulated outer wall of the orbit effectively resists this force which is reflected downwards on to the thin area of bone immediately overlying the infra-orbital nerve which 'explodes' into the underlying cavity of the antrum. A blow received upon the inner aspect of the superior orbital margin will involve the frontal sinus. This is not developed in early childhood and direct communication with the anterior fossa of the skull readily occurs in this location. Penetrating wounds, where the point of entry may easily be overlooked, may be followed by the development of fulminating meningitis. A blow directed upon the outer aspect of the superior orbital rim will often lead to fracture of a well defined segment related to the deeply recessed area in which the lachrymal gland is lodged.

Fractures of the middle third of the face are comparatively unusual in children. Those which do occur usually only involve the nasal skeleton and occasionally in older children the zygomatic complex. In general there has to be a very severe degree of trauma to dislodge the maxilla. A number of factors contribute to this relative immunity, such as the smaller proportion of facial : cranial bone, the relative rate of growth and the plasticity of the bone and the relative prominence of the frontal bone.

The overall incidence of recorded injuries recorded in this series support this basic view of structure and function. There are though some anomalies in the incidences of recorded injury. These are all a direct result of the decision to score only actually recorded injuries without trying to interpret the report of the investigating pathologist.

Inevitably this has meant that some injuries are under-reported. Occular (less than 1%) and nasal injury incidences are not in accord with the number of grade 3 and 4 middle third injuries. By their severity these imply gross Le Fort type III fractures which are characterised by widespread destruction. Similarly, although there were 21,9% grade 4 fractures of the base of the skull only 0,23% grade 4 middle ear injuries were reported. In many cases there was widespread damage to the skull,

but when the description was carefully read, no mention was made of the middle ear. It could be that there was no damage, but this is unlikely. Another anomaly is the number of grade 4 mouth injuries (0,23%), when there were 1,58% and 4,45% mandibular and maxillary fractures of this severity. In this case the disparity is easy to explain, for many people do not routinely record damage to the mouth because they either feel that it is not important or they feel that it is covered by the descriptions given elsewhere.

Undoubtedly these deficiencies are important and they do detract from the value of the information gathered as a record of the incidence and severity of injuries sustained in aircraft accident. Arguments that these may not always be recorded when writing reports for other purposes do not remove the deficiency, nor do they make it any easier to accept. Forensic science deals with the careful recording of each and every injury. It is true that in many cases, damage to these anomalous areas could have been inferred and that, as far as the purposes for which the original report was intended, they do not comprise a serious detraction.

That facial injury is a serious problem in aircraft accidents, despite the anomalies, can be seen from the fact that at least 71,5% of all victims sustained damage here. As all facial injuries, whether they be to the soft tissues or to the bony skeleton, are a result of contact, the seriousness of the situation is underlined.

Vulnerability to injury is a function of anatomy, pathophysiology and the environment. The former two categories can be considered as one, namely tolerance, which is affected by age, disease and the basic structure of individual tissues. These effects have been well documented in the literature but are not totally understood.[5] Probably the single most significant contribution to this lack of comprehension, results from the failure of accident-injury researchers to standardise their methods.

Facial tolerance has been studied by a variety of workers, some of whom have produced values as a by-product of investigation into head injury. The most commonly quoted values are given in Fig 2. Other workers such as Schneider and Nahum[6] and Warner and Niven[7] have given values for tolerance in ft lbs and Newtons. Thus they illustrate the lack of agreement about the units of measurement to be used in tolerance studies.

The differences in these values do not necessarily infer that the quoted values are wrong, as they may only reflect individual variations. However most authorities seem to accept Swearingen's[8] findings and these do seem to agree with the observations made when analysing accidents.

As far as the environment is concerned, the relationship between it and injury is much easier to understand than are biological factors. Force has to be transmitted to a bodily part if it is to cause injury. Unlike the brain where motion may result in injury, the facial tissues require that physical contact be made, though motion does regularly

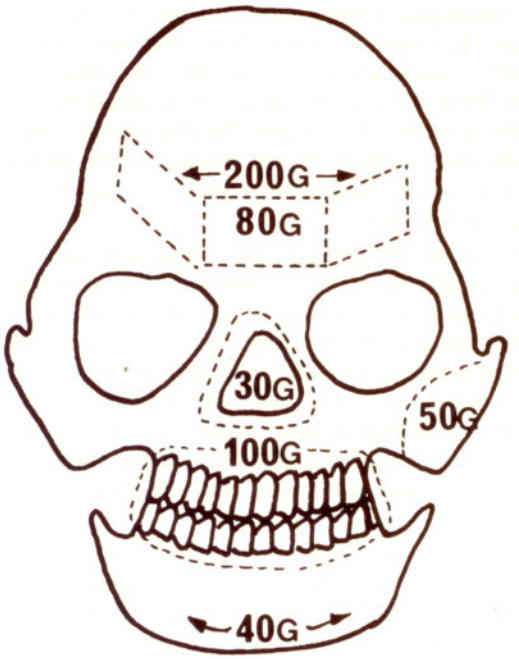

Fig. 2. Facial Tolerances — Various sources.

cause occular damage and with high rates of rotation petechial haemorrhages may occur in the facial tissues.

Direct contact with the backs of seats, cockpit comings, instruments and other structures is the commonest cause of facial injury. When this occurs it can be said that, in that case, restraint failed. It is important to know how often this does occur. If it is assumed that fractures of the skull and facial bones are an indicator of direct head contact, then in this series it occurred in 55 - 60% of victims, allowing for the fact that vertical forces cause severe skull fractures. As the implications of this are discussed elsewhere, suffice it here to say that the possibility of head contact because of inadequacy of restraint is a worrying feature.

The overall severity of facial injury is added to by those cases in which there were serious fires. Even so, the finding of 18,6% of serious and fatal injury to the facial tissues is disturbing.

One of the remarkable findings in the incidence of facial injury, apart from its frequency and severity, is its symmetry. It may be implied from this that, in all probability, loose objects are not a common cause of injury.

Injuries to the mouth and teeth tend to be reported when there is severe damage to the facial bones and are rarely mentioned in other circumstances. This could mean that they are well protected, but the ease with which such injuries occur in other activities tends to discredit such a suggestion. Diagnosing dental damage in dead people can be

difficult as root fractures, disruption of the pulp and some alveolar fractures may not be readily apparent. It is not usual for their diagnosis to be delayed in the living unless radiographs and pulp testing are undertaken. Vertical impacts, even on clenched jaws, can result in very high loadings upon the teeth and their supporting structures. When this occurs there is a very real danger that tooth fragments and, or bits of fillings may be dislodged and become impacted in the air passages. Bleeding from lacerations in the oral mucosa and difficulty in speaking because of a torn tongue are hazards which may make the differences between living and dying in an aircraft accident.

Injury to the tongue is in many casees due to 'biting'. Lacerations to the oral mucosa may be due to either distraction of the fractured bones of the jaws or less frequently to loose objects. It must not be forgotten that many people have dentures which are more brittle than natural teeth. When they break they produce sharp fragments which can tear the mucosa or they may be inhaled. Generally though, the cheeks and jaws do seem to be protected from injury although the frequency with which this occurs cannot be given and frequent finding of whole dentures, both partial and full, suggests that this is not uncommon.

The skeletal location of the malar or sygoma seems to protect it from serious injury and there are significant differences between the incidence of fracture to this bone, the mandible and the maxilla. It is interesting to note that the vast majority of recorded fractures were of grades 2 and 3 (36% and 60% respectively ignoring those which were totally disintegrated). In the maxilla there was an almost equal number of grades 2 and 4 fractures (24,1% and 23,9%). Also 9,25% more people suffered maxillary injury than they did fractures of the malar. There are two explanations for this: either the maxilla is weaker or the malar is less exposed. Impact tolerance figures indicate that the malar is twice as strong as the maxilla and if strength were the only factor, we should expect to see twice as many maxillary fractures. It must be remembered however that tolerance figures, such as those quoted, are really threshold levels and we are dealing with various grades of injury. Moreover the lateral position of the malar may afford some degree of protection.

Equal numbers of grade 1 injury were observed, one of each, on opposite sides of the face. The frequency of injury increases as does the severity with increasing intensity of impact (Table 3). As the injuries tend to be symmetrically distributed, this suggests that the potential for injury is dependent upon position as well as strength. Moreover, it supports the view that injury to the face is largely a result of antero-posterior forces and that this is due to contact with some part of the aircraft or other structure.

There are differences in the rates of injury due to the mechanics of the crash. The forehead hits the aircraft first, followed by the maxilla and finally the mandible. Greater impact forces are needed to ensure that all three make contact rather than just one or two areas. It also explains why the majority of fractures of the mandible are in the horizontal rami. Malar fractures occur because of force transmitted firstly through the maxilla and also by direct contact. Because the bones are further away

from the point of impact the injuries are likely to be less severe and more serious fractures will be associated only with a highly destructive impact. Similar arguments hold true for the mandible.

The effect of the intensity of the impact can be seen from Table 3. If it is acknowledged that, as discussed previously, the quoted incidences of nasal and oral injuries may be low, then the increase both in frequency and severity of bony injury is marked (Table 3).

Here, only grades 1 - 4 are considered because the intensity of injury to the whole body in accidents where there is total destruction of the body is obviously extremely high and therefore meaningful results are less likely. Quite clearly though, there is an obvious relationship between the intensity of impact and the causation of injuries. Moreover, as can be seen from the tables, the increase in the severity of injury as well as the frequency, mirror and therefore confirm the relative susceptibility of the various bones to trauma. They also confirm the view that it is the upper face which first contacts some parts of the aeroplane's structure during an aircraft accident.

Conclusions

Maxillo-facial injuries are common in aircraft accidents. Their frequency and severity is related to the intensity of impact and the strength of the variam bases. Nasal and intra-oral injuries are probably under-reported.

In view of the potential seriousness of maxillo-facial injury, both in its capacity to cause immediate death and to impede escape, this high incidence of injury represents a failure in safety design of aircraft.

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The Investigation of Charred Skeletal and Coffin Remains: A Case Report

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Abstract

The grossly charred skeletal remains of a human body and the soil collected from around the body was examined. Two molars present in the mandible showed evidence of occlusal cavity preparations and the remains of amalgam restorations. Complete and partially fragmented enamel shells, teeth and fragments of teeth were found in the soil in addition to steel nails and staples similar to those used by coffin manufacturers. Hundreds of well preserved charred maggot shells were found loose or adherent to the bones. All the findings indicate that the body and coffin were exhumed while in a state of decomposition, possibly for use in witchcraft, and subsequently set alight to try and destroy the evidence.

Keywords: Forensic Dentistry, Burn, Witchcraft.

Case Report

The grossly charred skeletal remains of a human body were recovered near Chatsworth, Durban by the South African Police. Among the bones recovered were the skull which had a patchy covering of heat coagulated tissue and mandible which was fractured in the 45, 46 area. The maxilla was detached and split in two along the mid-palatal suture.

The following teeth were present in the jaws: 18, 17, 16, 26, 27, 28, 38, 37, 36, 35, 46, 47 and 48. The sockets of the absent teeth showed no evidence of alveolar bone resorption indicating that they had been lost peri- or post-mortem. Fifteen other loose charred teeth were also recovered. Many of the teeth had lost their enamel either partially or completely. The scorched enamel presented as complete or partial shells which had come away from the underlying dentine core[1] (Fig. 1). To a casual observer these enamel shells looked like artificial crowns and on inspecting the dentine cores their appearance suggested that crown preparations had been completed on these teeth. The fragments were examined radiographically and the results revealed that they were indeed enamel (Fig. 2).

Sex Determination

On examining the skull, maxilla and mandible the following features were noted:

Fig. 1. Teeth with intact dentine cores and complete enamel shells.

(1) Moderate frontal and parietal bossing.
(2) Small supraorbital ridges.
(3) Sharp orbital margins.
(4) Small mandible.[2]
(5) Mandibular gonial angles not everted.

These features together with the findings in the rest of the bones indicated that the skeleton could be female.

Age Determination

Lateral, antero-posterior skull and full mouth periapical radiographs were taken and the completeness of root formation of the four wisdom teeth was observed. An estimated age of approximately 22 years was determined.

On examining the soil and rubble recovered with the skeleton, steel nails with flattened heads as well as steel staples were recovered (Fig. 3). The nails and staples were similar to the type used in the manufacture of wooden coffins including securing of the plastic lining of the coffins. Hundreds of charred but well preserved maggot pupal shells were also present in the soil or attached to the bones. These findings all point to the distinct possibility that the coffin containing the body was exhumed sometime after burial and then set alight.

Discussion

The relevance of finding nails, staples and pupal cases with a charred

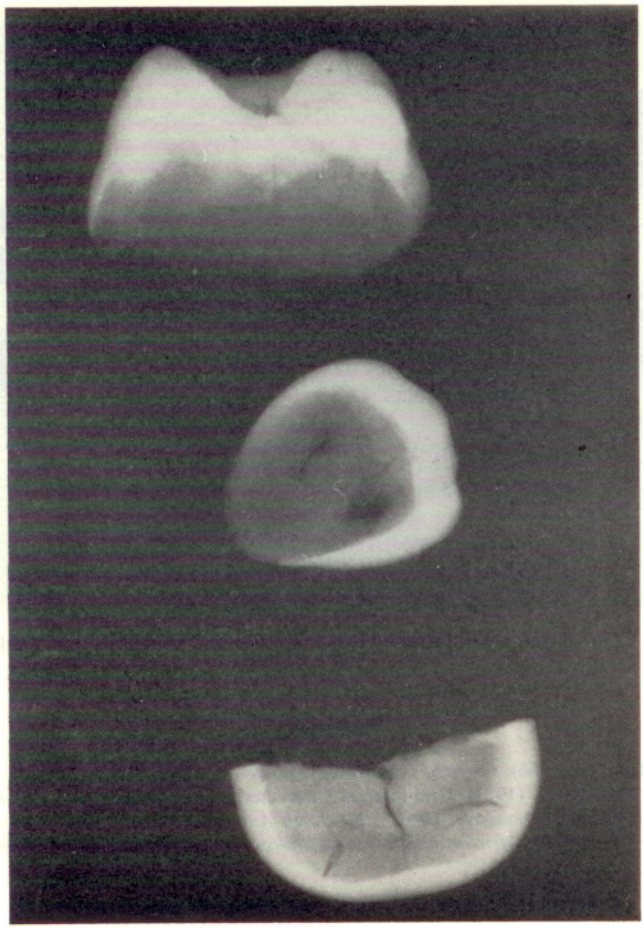

Fig. 2. Radiograph of enamel shells.

skeleton can only be speculated upon. A conventionally interred body could have been exhumed after it had decomposed and been infested by maggots. The local indigenous population is given to witchcraft in which human organs play an important role[3] and in this case the possible source of tissues could have been burned to destroy the evidence. The recovery of soil from the site yielded important material, that is, the teeth, tooth crowns, nails, staples and maggots. The Durban police are to be applauded for this thoroughness in their recovery procedure and it is recommended that all police officers should be aware of the importance of gathering up all objects which might in anyway be helpful to forensic scientists. Isolated teeth are a common and particularly good example and are often of vital importance in an investigation.

I wish to thank Dr. N. Hodges for the photographs and Mrs. L. Figenschou for typing the manuscript.

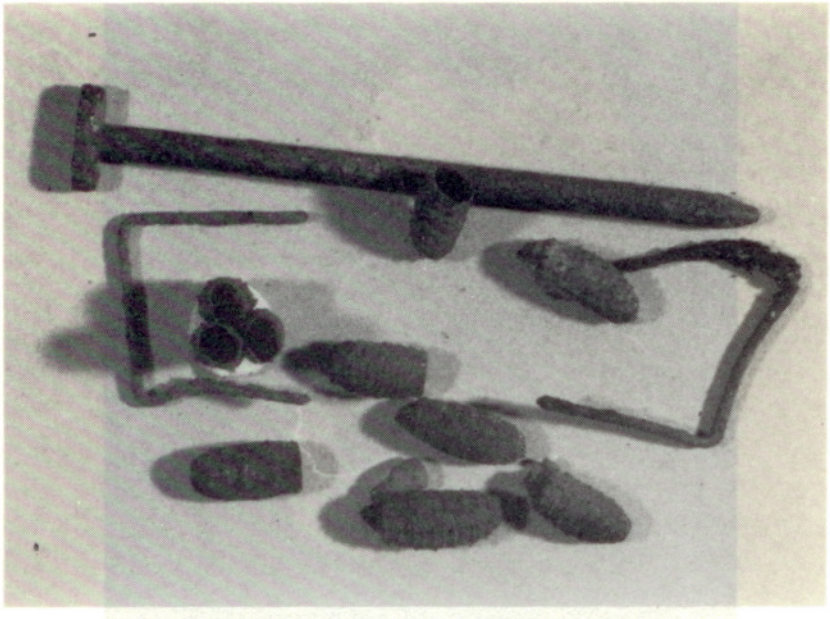

Fig. 3. Steel nail with flattened head, staples and maggot pupal shells.

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Aids in Dental Practice: Hazards, Infection Control, Medico-legal and Ethical Aspects

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Summary

Dental manifestations of AIDS are discussed, along with certain recommendations regarding infection control. Special reference is made to prevention and health questionnaires for detecting high risk individuals. Reference is also made to the literature regarding ethical and medico-legal issues with respect to the practitioner, the patient, the researcher and the health care worker. The need for public health educational programmes aimed at high risk groups, researchers, Health Care Workers and the general public, with special regard to the spread of infectivity of the disease, is discussed and problems experienced in obtaining emergency dental care in Cape Town for certain patients confirmed to have the virus infection are identified.

Introduction

The origin, causes, diversity of clinical aspects, infectivity and transmission of AIDS (the Acquired Immune Deficiency Syndrome) have been discussed in detail in numerous review articles.[1] There is no longer any doubt that this is a blood-borne viral disease, caused by the Human T-cell Lymphotropic Virus (HTLV-III) as described by Gallo[2] and considered to be identical or very similar to the Lymphadenopathy Associated Virus (LAV) which was previously described by French researchers.[3,4]

Since the disease was first described in 1981[5] it has spread with alarming rapidity throughout the world with serious public health, social, personal and economic implications. The first 10 000 confirmed cases of PWA (persons with AIDS) in the United States are reported to have cost an estimated $6,2 billion dollars in medical expenses and loss of manpower through premature death.[6]

From the initial high risk groups of homosexuals, haemophiliacs, intravenous drug abusers, Haitians and bisexuals, the virus has spread into all sectors of the general population, albeit still in much smaller numbers, so that infection has been reported from most European countries as well as from the Venezuelan Amazon,[7] Sri Lanka,[8] Saudi Arabia[9] and South Africa.[10,11] In Central Africa the disease is mainly transmitted heterosexually, with an equal ratio beteen males and females.[12]

As there is as yet no successful drug available against the virus infection, no successful therapy for the Immune Suppressed State resulting from it and no hope of a successful vaccine in the near future,[13] the only "cure" for this disease lies in prevention.

The role of the dental profession should therefore not only include efficient control measures to prevent the spread of the disease between patients and dentists but should include the education and enlightenment of its staff and patients. This role is preventive and community health medicine does not only belong to particular departments of medical schools or the State but to every individual involved in the health care of people. A quotation from the literature emphasises this aspect convincingly: "In the meantime we must communicate patiently and clearly to a frightened (and uninformed) public what we know and what we are learning. As always happens in times of panic, fringe groups are arising to raise the level of static and make the message hard to hear, and we will have to shout our message of prevention."[14]

The duty of the medical profession to inform the public is expresed in an editorial of the British Medical Journal stressing that there are no grounds to suggest that transmission occurs via the air or via casual contact "or to put it simply, by sharing a bus or a waiting room, or by talking to or shaking hands with a patient with AIDS".[15]

The Case Against Casual Contagion

In the light of numerous scientific publications proving the low infectivity of the disease which is mainly a bloodborne disease spread by blood and blood products or intimate sexual contact, it is now universally accepted that the virus is not easily transferred. Although the virus has been demonstrated in saliva[16] and tears[17] there are no cases on record of infection via this route. The presence of the virus in breast milk has been postulated as a possible means of transfer to an infant while the demonstration of the virus in intermenstrual vaginal secretions[18] are considered to be the reason for transmission in heterosexual sexual intercourse. It is *NOT* transferred by touching, sharing of general household, culinary, transport or ablution facilities.

Seen in the light of studies showing lack of casual transmission of the virus from a PWA to members of the family or household[19,20] the danger to patients sharing the waiting room of the dentist must be non-existent. The minimal risk of transmission and of the occupational hazard to health professionals, even after accidental injury with contaminated needles, was confirmed by a recent study of 1 750 such injuries as not to be a serious risk.[21,22]

Aspects of AIDS of Relevance to Dental Practice

I. *Diagnostic Aspects*

It is now well known that a number of lesions may be present in the mouth, and may very well be the first indication that the patient may be infected by the HTLV-III Virus, with immune suppression and ARC (the AIDS-related complex) or AIDS. These include Kaposi's sarcoma,

Candida infection causing thrush unrelated to antibiotic treatment, hairy leukoplakia of the tongue and herpetic lesions.[23] It is important to recognise these from an early diagnostic as well as infection control point of view.

Hairy leukoplakia is of diagnostic importance in the early diagnosis of HTLV-III/LAV infections, especially in combination with other clinical findings. Clinically it is characterised by raised white areas, usually of the lateral border of the tongue, and may not respond to traditional anti-fungal treatment. Apart from Candida on the surface of these lesions, a number of viruses, including Papilloma, Herpes and Ebstein-Barr have been identified by electron microscopy.[24]

It is stressed that while careful histories and physical examinations alone will not identify persons with AIDS or related symptoms, oral findings, including this newly reported oral lesion, are important diagnostic tools for health care providers in early identification and treatment of AIDS.[25]

Greenspan and his co-authors[26] also report that in a series of 123 patients with hairy leukoplakia 11% had AIDS at the time of diagnosis. Eighty of the remaining 110 of the group were followed clinically and 20 of those (25%) developed AIDS within 1 to 33 months, with a mean period of 7,5 months.

Infection Control in the Dental Surgery

General aspects of infection control are well discussed by Blignaut.[27] There is however specific action that should be taken when AIDS is involved.

A. Screening of Patients Before Dental Treatment

1. Health Questionnaire

It is highly recommended that all dental patients should be required to complete a general health questionnaire of his/her present and past medical and dental history. On subsequent visits the patient should be questioned again about recent or present symptoms. This document should be completed before any treatment or oral examination is performed and should be considered as a routine aspect of any dental practice. The principle of patient confidentiality must of course also apply to this questionnaire as it does for all medical records.

Apart from routine questions such as the name and address of next-of-kin and marital status and questions regarding general health status, this document should also contain questions on symptoms indicative of HTLV-III/LAV infection, including unexplained, rapid and considerable weight-loss over a short period, unexplained persistent diarrhoea, unexplained drenching night sweats, sore throat, persistently painless swollen glands, especially in the head and neck region, recent skin rashes, resistant athlete's foot or other fungal infections or fever blisters in the mouth and on the lips.

It would also be of value to establish whether the patient is or ever was a blood donor, including his bloodgroup. Since all donors are now

screened by blood transfusion services and high risk individuals excluded by means of a similar questionnaire, and routine testing of donor blood for antibodies to HTLV-III, this may assist in recognising a high risk individual.

2. General observations during introduction

The practitioner may observe evidence of any skin lesions on the face, hands or arms which may be due to fungal infection or Kaposi's sarcoma, and enquire about its duration and origin.

3. General head and neck examination of patient before treatment

It may be of great value to examine the patient's neck and occipital region for swollen glands. The patient may be reassured that this is regarded as a routine part of dental examination, as swollen glands may follow infection or malignant lesions in the mouth. The otherwise symptomless individual with ARC or the persistent generalised lymphadenopathy syndrome may be recognised in this way.

It is reported that approximately 95% of patients with AIDS or the AIDS-related syndrome have surgical lymphadenopathy and other head and neck manifestations of disease, which may be detected by dentists or others undertaking oral or facial examination.[28]

4. General oral examination

During the general oral examination the dentist, dental assistant or oral hygienist should be able to recognise lesions found in PWA like thrush, hair leukoplakia, tumours, and Herpes, as well as possible evidence of other sexually transmitted diseases, including gonorrhoea of the throat or even a syphilitic chancre.

B. Infection Control

Precautions to be taken by the dentist should be such that even the unsuspected carrier will not be a danger, and therefore it has been recommended that general Hepatitis B control measures be taken.[29] These should be well-known to all informed practitioners and may be summarised in the following main categories:

Injection Needles

Needles should NEVER be resheathed. Syringes and needles must be disposed of in rigid, puncture-resistant containers. The main hazard from needle-prick injuries is the accidental injection of blood containing viruses. As most needle-stick injuries are reported to occur when the needle is being resheathed or re-capped, the use of a recently described device to reduce this hazard, may be worth investigating. The "Needle Guard" is a plastic shield with a central hole into which the covered needle is placed before disposal.[30]

Masks

The wearing of masks by all dentists when dealing with any patient is recommended.[27] This is a general hygienic principle for the protection of dentist and patient and for the comfort of the latter.

Eye Protection
To prevent droplet infection protective eye wear is recommended where spattering of blood, secretions or body fluids may result, as is very often the case in the dental chair. It is suggested that ordinary clear glass spectacles may be used instead of anxiety-producing goggles, unless the patient is known to be a PWA or ARC, or to have a positive HTLV-III antibody test. The use of eye protection may also prevent foreign body injuries to the eyes of dentists and assistants, and should be considered as a routine safety practice.

Gloves
Although gloves may interfere with the sensitivity of the fingers, they should be used where the dentist has any open wounds on his hands or where a real risk may exist of accidental injury during particularly difficult surgical procedures. In the case where the patient, or the dentist or assistant are known to be high risk individuals, carriers or sufferers from the disease gloves should be worn at all times.[31] Blignaut[27] however recommends the routine use of gloves, and the institution of this principle during dental training.

Utensils
Although the sharing of utensils is normally not accepted as a risk in the spread of HTLV-III/LAV, the use of disposable cups for mouth washing should be instituted as a routine in the normal hygiene programme of any dental practice irrespective of the state of the patient.

Disposable Items
The use of disposable saliva ejectors and other instruments is advocated where possible and together with all swabs and contaminated materials should be placed in thick plastic bags before despatch, preferably for incineration, in order to avoid the risk of injury and infection to cleaners and workers, especially where the more real danger of transfer of Hepatitis B is concerned.

Sterilisation
Disinfection and sterilisation of instruments should be an indispensable routine in every dental practice. From personal enquiries and experience however it is this author's opinion that generally speaking sterilisation is inadequate in dental practices and has been neglected by too many dentists for too long. Recommended methods of sterilisation are set out in Table I.

It is very important to realise that sterilisation personnel should be protected routinely against infection and injury while handling instruments by the wearing of gloves, masks and eye protection, not only if splashing is anticipated, but also to prevent injury while cleaning sharp instruments.

C. Ethical and Medicolegal Considerations Concerning Dental Practice

AIDS manifests itself in many ways and every branch of health care services is implicated in one or other ethical and medico-legal aspect.

Table I. Suggested Sterilisation Methods for Dental Practice

A. Instruments
1. Should be cleaned thoroughly prior to sterilisation or disinfection to remove blood
2. Heat
   1. Autoclave 121°C 15 minutes
      126°C 10 minutes
      134°C 3,5 minutes
   2. Dry air oven 121°C 16 hours
      140°C 3 hours
      160°C 2 hours
      170°C 1 hour
   3. Boiling for 10 to 30 minutes
3. Chemical methods:
   1. Ethylene oxide gas 4 - 16 hours
   2. Glutaraldehyde 2% freshly prepared solution for 1 hour
   3. Sodium hypochlorite solution for 30 minutes (may be corrosive for metal instruments)
      * 10 000 ppm for spills especially on porous surfaces. Operator must wear protective gloves.
      * 2 000 ppm for general cleaning of surfaces and inanimate objects without definite spill.
   4. Ethanol 70% for one hour. NB: take care near electrical appliances and open flames
   5. Formalin not effective at low concentration

B. Surfaces: after spillage: * sodium hypochlorite: 10 000 ppm
routine disinfection: * Sodium hypochlorite: 2 000 ppm
or * Glutaraldehyde: 2%

C. Anaesthetic masks, mouth-, oral- and naso-pharyngeal or endotracheal airways, Y-pieces, corrugated tubing and dental suction tubes, should not be placed amongst clean instruments of the anaesthetic or dental tray. If not disposable, these should be thoroughly washed before gas sterilisation.

The Dental Practitioner

1. Avoid transmission by safe dental practices

It is reasonable to expect of any health care worker, including the dentist, that a safe service is provided and that all *REASONABLE* steps to achieve this goal are taken. With our present knowledge of the spread of the disease and the evidence against casual contagion, it is nevertheless necessary to maintain the standards of hygiene as discussed above.

2. Retain confidentiality

As already stressed the confidentiality of the contents of the patient's dental record and information must be maintained and unless revealed with the patient's consent would be regarded as breach of contract.

The importance of epidemiological statistics in research and for health prevention programmes, however, may mean revealing the diagnosis to a professional which is considered acceptable and desirable provided that the patient's identity is *only* revealed with his informed consent. I quote here from a statement by the Medical Association of South Africa on confidentiality of medical records:

"The medical profession regards confidentiality between doctor and patient as a matter of paramount importance. This concept is embodied in the South African Medical and Dental Council's regualtions and our law also demands that a doctor respect his patient's confidences. Only if ordered to do so by the presiding officer in a court of law, and under protest, shall a doctor disclose information regarding his patient. The MASA regards any circumvention of this protection of confidentiality as a serious breach of an ethical rule."[32] The realisation that certain exceptions to the confidentiality rule may arise and are accepted by the British Medical Association and General Medical Council, has recently been discussed by Gillon[33,34] and may therefore in exceptional cases be of application to PWA.

The Patient

In terms of common law and relevant sections of the Immorality Act, No. 23 of 1957 (as amended) certain homosexual acts between consulting adult males are illegal in South Africa. Although highly unlikely, the patient may theoretically therefore be prosecuted for having contracted a disease by commission of a crime.

Some individuals have lost their employment after contracting the disease, either from being too ill to work or because of their sexual orientation. A number of legal aspects should therefore be considered.

1. The patient may presumably take civil action for wrongful dismissal.

2. He/she may also be entitled to an unemployment allowance from the Department of Manpower and when too ill and debilitated to work, to a disability pension from the Department of Health and Welfare.

3. It is conceivable that the patient may institute civil action against a person, or company, including the dentist or dental practice, responsible for transmission of infection.

4. Similarly, civil action may presumably be instituted against a person who, conscious of the fact that he/she is a carrier of, or suffers from the disease, transmits the virus to somebody else in some way. In this regard valuable service has been rendered by concerned private persons and groups in advising carriers of, and sufferers from the disease, to inform their doctors and dentists that they are aware of their condition. An ideal state of affairs could only be achieved if patients can feel free and comfortable to confide in their health professionals without fear of exposure or bias.

5. In the worst possible situation where the patient dies from transfusion or iatrogenically transmitted AIDS, it may be considered to be death from a non-natural disease in terms of the Inquest Act of 1969, wherein it is stated that "Any person who has reason to believe that another person has died and that such a person has died from other than natural causes, shall immediately report accordingly to the nearest policeman."

The Inquest

At a subsequent Inquest the magistrate may find that "Death was

brought about by an Act or Omission amounting to an offence on the part of any person."

This could mean:

1. The high risk individual who omitted to (re-) establish whether he/she has become infective in order to prevent the spread of the disease by appropriate preventive behaviour.

2. Omission of a patient or carrier to refrain from blood, semen or organ donation or to inform the health care worker or sexual partner of his/her infective state.

3. Omission of the transfusion service who may have omitted to take reasonable action in screening of blood units in order to ensure a safe product.

4. Omission of the hospital, dentist, medical practitioner or other health professional to take essential, effective and reasonable preventive measures.

5. An act of co-mission would be a possibility where an infective individual knowingly and deliberately spreads the disease by "unsafe" sexual behaviour or the donation of semen, blood or organs. In this regard the importance of education and readily available information about this disease to all sectors of society is stressed by Grouse[31] who maintains that "providing individuals, in circumstances under their own control, with the information that allow them to prevent the further spread of AIDS, is most consistent with a free society."

6. Furthermore, if at a subsequent inquest it is found that death has been brought about by an act or omission amounting to an offence on the part of another person (or hospital) the Inquest record will be referred to the Attorney-General who may decide either to prosecute or to refer the matter for a departmental or statutory body enquiry.

These complex medico-legal issues may be followed by litigation where, in contrast to civil actions where a finding is made on a "balance of probabilities", in a criminal procedure it must be proved "beyond reasonable doubt".

Some Ethical Considerations

1. The Patient

He/she has the same right a) to unbiased and sympathetic treatment and care as any other patient suffering from a disease caused by habits or lifestyle (smoking and lung cancer, liver cirrhosis and alcohol); b) to be informed about his condition and the prognosis at various stages of the disease; c) to decide when treatment and invasive diagnostic procedures must be stopped, especially in the light of the present absence of drugs against the virus and the suppressed immune state. This aspect of patient autonomy is described as the most important facet in allowing the patient to die with dignity.

If these ethical principles regarding patient care are maintained it may lead to the state of mind that inspired a patient with AIDS to say "I feel good. I feel I'm learning things for my spirit. Don't call us AIDS patients, don't call us AIDS victims. AIDS is not my weakness, AIDS is my strength."[35]

2. The hospital, doctor and health care staff

a) Refusal to treat a PWA or any of the related clinical forms of the disease would be regarded as unprofessional and unethical behaviour.

b) The question pf whether any health employee should be compelled to participate in the treatment of a PWA or the virus infection, or to handle the body of such a deceased, has arisen (this includes the dentist and other health care workers in full-time service). The correct answer would be to ask for volunteers who would be more likely to provide better understanding and sympathetic handling of the patient. It remains essential, however, that safe protective working conditions and precautionary measures must be available.

3. The researcher

Rarely in medical history has research been more intense than in this dreaded and frightening disease and each unfortunate person with the virus infection has become a potential source of material for research. On the other hand he/she has supplied the "Window of Opportunity" for medical research and deserves the highest ethical standards during investigations.[36]

As with any other medical or dental condition it is only with the full, informed consent of the patient that diagnostic, therapeutic and research procedures should be carried out, especially where invasive procedures like lymph node, jejunal, oral and bronchial biopsies are performed. The principle applies especially when a patient is moribund or when statistical confirmation is required.

By maintaining ethical standards in research and health care into all aspects of AIDS the medical and dental profession may join Victor Frankl[37] in believing that "man can find meaning in the midst of suffering by turning a predicament into a human achievement."

4. The health care worker

It is important to point out that involvement in the care of PWA may become a positive experience towards the growth and emotional maturation of the health care worker himself/herself as expressed by one such an individual regarding her patient: "I knew Ron for less than five months. I watched him fight — to stay alive, to stay independent, to remain lovable, to be involved in his treatment, to live, and finally to die. He taught me of dignity in the face of indignity, about living life while being stalked by death, about fighting battles no-one knows how to win."[38]

5. The doctor as counsellor

Leach and Whitehead[39] point out that non-specialists are likely to become involved in continuing care of PWA. Patients in all categories may present with the same degree of anxiety and seek information on a whole range of problems, medical, psychological and psychosexual.

The mediating role of the doctor in the important aspects of counselling and support to the PWA, ARC or the AIDS-related anxiety state, is well discussed by Isaacs and Miller,[40] who consider that this role can be effectively played by the informed and caring general practitioner.

An editorial in the British Medical Journal[15] concludes that "doctors have a responsibility to put the record straight and help people to view the disease in perspective; patients with the disease not only need our professional help but also our sympathy and understanding."

In candid terms Professor Chris Barnard[41] expressed himself on the topic of AIDS and stated: "to those who live in fear of contracting AIDS from a drinking glass I repeat what an old medical school lecturer told his students when asked about the dangers of contracting venereal disease from lavatory seats: 'What a helluva uncomfortable place to have sex'."

Reactions and Experience in the Western Cape by this Author

Examples of the enquiries and experiences of this author in the western Cape illustrate some of the numerous problems encountered and the degree of ignorance regarding AIDS among the general population and professional people. Despite the relatively small number of PWA or ARC to date in South Africa, and particularly in the western Cape, where only 2 deaths have so far been reported by Spracklen *et al.*[10] a much more serious situation is predicted if the spread of the disease is not contained.

1. A patient with AIDS related complex (ARC) required a confirmatory lymph node biopsy, and shortly after that an emergency cholecystectomy. After initial problems and discussion of the infection control measures to be taken, these procedures were carried out in a private hospital with the full knowledge and consent of the surgeon, anaesthetist, hospital and nursing staff who took the necessary precautions.
2. Certain private dental practitioners have on two occasions refused to accept AIDS patients who required emergency dental treatment. The service was eventually rendered, and is now available at a State dental clinic where the fully informed staff took the necessary precautions.
3. A benign fibrous histiocytoma on the leg of a patient with immunosuppression was misdiagnosed as Kaposi's sarcoma. The mistake was discovered four days prior to the commencement of radiotherapy after two weeks of emotional and psychological stress to the patient, requiring psychiatric counselling. Civil action for unnecessary pain and suffering may have followed in a litigation-conscious patient and country.
4. A general practitioner asked for advice regarding four patients with positive HTLV-III tests, who subsequently consulted him for treatment of other sexually transmitted diseases (2 with rectal gonorrhoea) indicating that despite good counselling against "unsafe" sexual practices, and possible spreading of the virus, they had not desisted from or changed their sexual practices. The possibility that practitioners may ask for an ethical ruling by MASA to accept exceptions to the rule of patient confidentiality when it is in the interest of society, in a similar fashion as discussed by Gillon,[32,33] cannot be excluded. Doctors who suspect such behaviour, in spite

of warnings to and counselling of the patient can then report it to the local health authority for control measures.

5. An example of gross breach of confidentiality is suspected in the case of a PWA who alleged that he learnt from his friends in a club that his test for antibodies against HTLV-III was positive before being informed thereof personally by his so-called "sympathetic doctor". This has led to the belief among certain members of the high risk group in Cape Town that it may be preferable to avoid "high risk doctors".

The Role of Public Health in the Containment of AIDS

The Department of National Health and Population Development has appointed a Central Advisory Committee on AIDS, and also takes financial responsibility for laboratory tests in the diagnosis of sexually transmitted diseases. In the case of AIDS serological tests are available as a free service to medical practitioners for their private patients, when they are required to confirm suspected cases of AIDS, as well as where sound circumstantial evidence exists that the patient may have contracted the disease or belong to an epidemiological high risk group.[42]

With the expected increase in the incidence of PWA or ARC in all sectors of society, there still remains the urgent need for an easily accessible publication of facts on AIDS for the general medical and dental practitioner and his patients, mainly to allay the fears of casual contagion.

A comprehensive health advisory pamphlet for the lay person, and especially for the household which may have an infective member of the family, or even a confirmed sufferer og ARC or AIDS, has become critical. Constant enquiries are received regarding handling of soiled bed linen, clothes, excreta and general principles of infection control. The medical profession has been inundated with scientific reports from all over the world but the public in South Africa has had to rely largely on lay press reports with their varying standards of accuracy and objectivity.

Successful screening programmes for safe blood and blood products are in force worldwide and in South Africa. The sexual transmission of this disease should therefore be tackled through Public Health information programmes which have already been reported to have had considerable effect in the United States.[43,44] It is also strongly advocated by Acheson[45] that in the absence of a vaccine or effective antiviral agent, public education to help people avoid risky sexual behaviour and drug abuse is the mainstay of a policy for controlling the spread of infection. He also believes that such programmes must meet the different needs of the general population, of high risk groups and of adolescents. "They must also include facts of how HTLV-III *is* and is *not* transmitted, practical advice on its avoidance, and advice to infected persons to help them avoid infecting others .... People who have been at risk are unlikely to come forward in large numbers unless they are satisfied that confidentiality will be preserved and that the problem of financial detriment to sero-positive people has been solved".[45] Grouse[31] realises

that the issue of confidentiality remains the biggest stumbling block in the path of disease control. He believes that many persons who are infected would act to avoid passing the infection to others if they knew their HTLV-III status "but are unwilling to be tested because of their concerns about confidentiality."

The attention of the dental profession must be drawn to the excellent pamphlet on AIDS compiled by the AIDS ACTION GROUP of GASA 6010, the Cape Town Branch of the Gay Association of South Africa.[46] This is an updated version of the pamphlets first issued in early 1984 which were very favourably received by local Health Authorities.

The need for similar pamphlets to the medical and dental professions as well as to the general public, has become more and more obvious. This author has had the opportunity to address numerous audiences on some of the problems of AIDS, with particular reference to the medico-legal aspects of transmission of infection, preventive measures in medical and dental practice, and counselling of individuals with AIDS, AIDS-related complex or a positive test for HTLV-III antibodies.

From personal experience it is believed that, irrespective of the academic level of the audiences addressed, certain misunderstandings regarding this disease still persist and can only be clarified by relevant and up-to-date information from the medical literature.

The GASA 6010 Pamphlet is considered an excellent one to fulfil this need in the meantime. Although specifically addressed to the "high risk group" with special reference to the prevention of the spread of the disease, it has been drawn up in collaboration with medical advisors, so that all the facts are scientifically correct.

That the spread of AIDS in South Africa is presently occurring mainly among homosexuals is known and accepted. That it will spread to a greater degree in the heterosexual population, as it has done in other countries, can be safely predicted. The only question is how fast and how extensively. Although Echenberg[47] is uncertain about the efficacy of mass educational campaigns he believes that education should be launched without delay to limit the spread of the disease. Prevention rather than costly identification later of infected individuals is advocated. Grouse[31] assumes that in the United States the public debate and outcry about AIDS will accelerate at roughly the same rate as the increase in persons with the infection. He advises the health profession to face the issue of AIDS spread and to adopt effective public health measures before the level of public concern prompts "draconian measures of questionable medical value".

The Department of National Health and Population Development in South Africa is well placed financially and strategically to undertake the urgent task of national education regarding all aspects of AIDS. No less than a national effort will contain the spread of this frightening infective disease with no known cure.

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Maxillo-Facial Radiology in Forensic Dentistry: A Review

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Introduction

The first recorded description of the value of X-rays in forensic medicine dates back to the year 1896 when a certain Elizabeth Ann Hartley, a 22-year-old loom operator in a Lancashire textile town, was shot four times in the head by her husband. The "experimental" use of X-rays contributed to the identification of the four bullets in Mrs. Hartley's skull.[1]

Maxillo-facial Radiology plays an important role in the science of forensic dentistry. The radiographic appearance of the teeth and of the bone of the face is a permanent record of these tissues, even when the teeth and sections of bone have to be removed for histopathological examination.

Legal Aspects of Radiological Practice

In dentistry the use of X-rays raises several legal issues. The laws and interpretations thereof vary from country to country. Dental practitioners are strongly urged to make themselves aware of relevant laws and legal precedence which may affect their practice of dentistry.[2]

In terms of a proclamation in the Government Gazette No. 3991 of 31 August 1973,[3] every dental practitioner in the Republic of South Africa is required to *licence* the X-ray machine and the premises in which it is housed, to *register* himself and any other persons who routinely operate the machine in his practice as "radiation workers" and to arrange for all these "radiation workers" to be monitored for exposure to radiation by wearing film badges whenever they use the X-ray machine.

In addition, the dentist has to maintain a *register* of all "radiation workers" in his practice in which any radiation they receive, as detected by the film badge monitors, must be recorded; and a *register* of every X-ray examination carried out on patients.

It would not be possible to provide readers with a comprehensive description of all the laws and regulations which apply to the practice of radiology, but from a forensic point of view, one of the most important responsibilities of the licence holder is that a record must be kept of every patient exposed to X-radiation and that these records must be preserved for at least 5 years after the date of the last entry. This

information may be recorded in a special book kept for the purpose or, if more convenient, as part of the patient's clinical record.

The record must confirm details of the surname, forenames, age, sex, date(s) of the examinations, a brief note of the reasons for the examination, the area examined, the number of exposures made, as well as a summary of the diagnostic information obtained.

X-rays and negligence

In any allegation of malpractice, a radiograph can be a valuable piece of evidence. Radiographs are factual evidence. The use of radiographs has been so imprinted on the minds of the public, that a judge or jury will probably find the dentist negligent if he fails to use an X-ray picture. Radiographs of inferior quality should not be kept, but retaken for two reasons:[4]

1. These radiographs will be of no use as evidence;
2. They will reflect on the dentist's lack of ability as a practitioner which could cause irreparable harm to his reputation.

The most important legal aspect of dental radiographs is that they are invaluable in malpractice suits. Any attorney will hesitate to bring a suite of malpractice against a dental practitioner who has taken pre-operative and post-operative radiographs. He would know in advance that a case would be difficult to win and would probably try to settle out of court. A dentist who has treated his patient in a competent manner and who has taken comprehensive radiographs, should not be concerned as he has irrefutable evidence in his possession.[5] If possible, radiographs should be retained indefinitely as these records could be of value in the maintenance of a person's health during his lifetime and as a source of identification following death.

Identification of Victims

Initially, radiology assists in building a dossier on the person under investigation. The identification of a body by means of comparison of postmortem with ante-mortem radiographs is not new. The utilisation of radiographs for purposes of identification was suggested by Schuller in 1921[6] where he states that the paranasal sinuses provide a high degree of morphological variation. Culbert and Law[7] and Law[8] claimed to be the first to perform a positive identification on the basis of skull radiographs by identifying a body through a comparison of the post-mortem and ante-mortem radiographs of the mastoid sinuses.

The most valuable contribution of radiographs in the identification of multiple casualties was reported by Singleton[9] in connection with the "Noronic" steam ship disaster at Toronto, Canada on September 17, 1949.

Singleton was able to identify 24 of the 119 persons by obtaining radiographs of 78 bodies with mobile radiographic equipment within 48 hours of the disaster and later comparing these radiographs, as well as more detailed radiographs when required, with radiographs of suspected

victims during their lifetime. In these 24 individuals, radiography was the sole means of positive identification.

Skull Radiographs in Identification

Modern day forensic problems usually require the utilisation of methods appropriate for the identification of individuals recently deceased. In this regard maxillo-facial radiography is extremely useful in revealing additional characteristics of the maxillo-facial bones.

Cephalometric radiographs of the skull can constitute very accurate ante-mortem records. Sassouni[10] suggested the use of certain measurements on the skull radiograph when he selected a random sample of 100 post-mortem postero-anterior radiographs from the records of 498 military personnel. With the aid of a computer he was able, in ten seconds, to select the corresponding ante-mortem radiograph for each post-mortem radiograph from the 498 available radiographs.

Lateral and postero-anterior skull radiographs can offer additional information, particularly where there is evidence that the individual received orthodontic or other dental therapy prior to death.

In such cases, it is important to acquire lateral and postero-anterior radiographs of the skull to compare with those that the patient's orthodontist may still have in his possession. The lateral cephalometric radiograph can reveal architectural details of the skull and the morphologic details of the frontal, maxillary and sphenoidal sinuses. These sinuses vary so consistently that total individuality may well exist. This led Schuller[11] to propose a classification of the frontal sinuses from radiographs in a postero-anterior plane (forehead-nose position) and define seven characteristics, viz: (1) septum and its deviation; (2) upper border (scallop, arcades); (3) partial septum; (4) ethmoidal and supra-orbital extensions; (5) height from planum; (6) total breadth and (7) position of the sinus midline. The accuracy of his method has not been tested and it is not known whether it has been applied in practice.

He also points out the changes in the radiographic appearance of the frontal sinuses as a consequence of acute or inflammatory conditions, tumours and injuries.

An extensive investigation of more than 2 200 children revealed that no two persons had the same nasal cavity pattern[12] and it is presumed that these structures do not alter during life or even after disease.

Panoramic Radiography

There is an increasing tendency among certain armed forces and aviation companies to record dental details of personnel engaged in dangerous occupations. The additional visualisation of the areas of the body of the mandible beyond the periapical region, the ramus, the temporomandibular joint, the maxillary sinus, the stylohyoid complex and the dental surgeon's professional responsibility to the patient to provide the best care possible, have undoubtedly led many dental surgeons in general practice and various speciality areas to use panoramic radiology on a

daily basis. This results in good records of many patients and may prove to be of great value in forensic odontology.

Estimation of Age

Estimation of age from the dentition

The use of teeth as an indicator of age is well known and constitutes an important part of forensic investigations carried out on living persons, unidentified bodies and skeletons. The dentition, especially in earlier years, and the skeleton serve as the primary scientific source of the estimation of age.

The dental age of an individual can be determined by comparing the radiographic appearance of the developing teeth with standard charts relating tooth development to age.[13–18] Nolla describes ten stages of development for each tooth, as viewed on a radiograph and allocates points from one to ten to each of these stages, e.g. one point to a tooth whose crypt is just visible on an X-ray picture to ten points where root formation is complete. The total of points for an individual is compared with the tables and the approximate age can be determined.

It is clear that in infants and young children age determination to within a few months or even weeks is possible. Up to completion of development of the roots of the second permanent molar, at approximately 15 years of age, use can be made of the above-mentioned charts with confidence.[19] Between the ages of 15 and 20 years use has to be made of the radiographic examination of the third molar. Some consider its development to be too variable, but its use can help to narrow the investigation of missing persons down to one age group.[20] However, another study indicated a high correlation between the degree of tooth formation and chronological age,[21] while Engström *et al.*[22] who investigated the relationship between the mandibular third molar, chronological age and skeleton maturation, found strong correlations between these variables. A study by Harris and Nortjé[23] revealed that the direct measurement of the mesial root of the 48 on a panoramic radiograph could be used to ascertain the chronological age of a subject to within 31 months with 95% confidence and to within 40 months at a 99% confidence level. This study compared very favourably with a previous study in which the stage of development of the third mandibular molar root was plotted against chronological age.[24] After completion of the root of the third molar, little accurate information about age can be obtained from radiographs of the jaws and one has to rely on the appearance of other bones.[25]

Estimation of age from sutures

The use of skull radiography in the estimation of age from the cranial and facial sutures appears to be unsuccessful.[26] However, a survey of ossification and fusion of the sutures may be of value in the future when longitudinal, radiographic studies of suture closure may provide standards that are presently lacking.[27]

Estimation of age from the size of the skull
Radiographic cephalometric studies have suggested standards of facial size and proportions by age which may serve as a basis for comparison.[28–30] The range of normal variation is too large, however, to permit great accuracy and moreover, precise knowledge of the facial change due to ageing in the adult is not known.[26]

Estimation of age using sinus characteristics
The maxillary, frontal and sphenoidal sinuses provide sharply defined outlines easily recorded from lateral or postero-anterior skull radiographs and their developmental stages afford the possibility of assessment of age. These studies have yet to be undertaken.

Estimation of Sex

The determination of the sex of unknown human remains by means of maxillo-facial radiographs is more difficult than the appraisal of age[26] and the only systematic radiographic study of identification of sex based on adult skull characteristics was done by Ceballos and Rentschler.[31] They used a postero-anterior skull radiograph on which they measured four parameters: total circumfacial height, mastoid height, bicondylar width and mandibular width. They concluded from extensive tests that "sex can be predicted in 88 per cent of the cases by utilisation of these measurements".

Determination of Race from Radiographs

Determination of race from radiographs appears to be unsuccessful. The possibility that taurodontism is more prevalent in certain race groups requires further study but one report on the prevalence of taurodontia in Saudi Arabia showed that of 1 582 patients examined, 11,3% exhibited some form of taurodontia.[32] Other studies by Lasker and Lee[33] indicated that the pulp cavity in the Mongoloid race was exceptionally wide and deep while Bhatia[34] showed that it is possible to assign an unidentified skull to one of three major ethnic groups, viz.: Negroid, Caucasoid and Mongoloid, with a high degree of accuracy.

Dental Radiographs in Identification

Sprawson[35] and Simpson[36] were among the first to report the use of radiographs of the teeth in the identification of a person. The uses to which dental radiographs may be put in identification procedures are the following:

1) Direct comparison between ante- and post-mortem radiographs. This is the single most accurate and reliable source from which to identify human remains. It is essential, therefore, that all routine X-rays taken during the course of dental practice be adequately fixed and washed so that they may be of use long into the future. A periapical film is of greater value than a bitewing or interproximal view as it shows most of the tooth and surrounding bone which is

often distinctive and less likely to undergo change. Because the bitewing radiograph is most commonly used in dental examination it may emerge as the most important factor in an identification and it is prudent to include it when radiographs are published for identification purposes.

2) The post-mortem radiograph is used to enhance points of comparison and to reveal certain "hidden" details present in the jaws and teeth of the victim, which are not visible with the naked eye during oral examination. In this way endodontically treated teeth, retained root tips, the presence of impacted teeth, etc. can be revealed.
3) Visualisation of the ante- and post-mortem radiograph of a dental restoration enable direct comparison to be made regarding the morphology of the filling material.
4) When ante-mortem and post-mortem records are compared the points of similarity establish the identification but despite the number of concordant points, inconsistencies may exist or be incompatible with making a positive identification.

Important points related to radiological identification are the following:[25]

(a) *Tooth Shape*
Teeth are extremely variable in shape, and this variation is most apparent in the root. The root may be curved in various directions, or altered either by apposition of cementum or by resorption. Where the tooth has more than one root, the variation increases.

Congenital and acquired defects such as peg-shaped teeth, dens-in dente and hypoplastic defects may have been unrecorded in the original charting, but will be evident on the ante-mortem radiograph.

(b) *Caries and Periodontal Disease*
These two common dental diseases are not reliable in establishing identification, because they are progressive diseases. However, the treatment of a carious tooth will usually lead to a permanent and distinctive shape of the restoration. Apart from silicate and acrylic, most of the materials used to fill cavities or to restore crowns, are radiopaque. Even when found out of the mouth, but related to a body, restorations can be radiographed and compared to the X-ray shadow of the same restoration in the ante-mortem radiograph.

(c) *Endodontic Treatment*
When ante-mortem radiographs of root canal therapy exist, they are usually quite comprehensive, as the various stages of treatment of the tooth are radiographed. Root fillings generally have a characteristic shape and occasionally there may be material in the surrounding periapical tissues.

(d) *Extraction Sockets*
When a tooth is removed, the first radiological evidence of healing is usually fuzziness of the lamina dura due to resorption followed by new bone which is progressively deposited on the walls of the socket

until the cavity is closed. The new woven bone is then replaced by mature bone. In the early stages of calcification of new bone, the socket will have a granular appearance, due to tiny radiopacities which become larger and are eventually remodelled to establish a normal trabecular pattern. Throughout this period the lamina dura may or may not disappear, in addition to which the replacement of the granular appearance by a trabecular pattern may never take place. Therefore, it is unrewarding to attempt to date a socket by its radiographic appearance.

Roots retained in sockets after unsuccessful extractions, have a distinctive shape and are also useful for identification purposes.

(e) *Impacted and Unerupted Teeth*

If impacted or unerupted teeth are present they are of considerable assistance in identification. This is probably due to the fact that the impacted or unerupted tooth will have a special position in relation to the other teeth.

Metal implants used for retention of prostheses are distinctive in shape and can be of great assistance in identification.

(f) *Fractures*

Fractures of the jaw may be sustained:

(i) some time before death
(ii) in the course of an assault, leading to death
(iii) at the time of death, as in an aircraft accident
(iv) after death.

It may be of importance to establish at what time, relative to the moment of death, the bone was fractured.

(g) *Pathology*

The presence of post-surgical lesions or of pathology may be important, not only from the point of view assessing the cause of death, but also in the process of identification. Pathology causing either resorption or deposition of bone may be seen on the radiograph. If pathological lesions were known to exist or were under investigation before death, identification could be assisted by a comparison with ante-mortem radiographs.

(h) *Inaccurate Designation of Teeth*

The charting of premolars and molars often leads to confusion when one premolar or molar is missing. Because teeth tend to drift forward when the mesial neighbour is extracted, second premolars can be falsely designated first premolars or, more commonly, first or second molars are described as second or third molars respectively. Third molars, however, are usually smaller than the other molar teeth which may be obvious on the radiograph.

Radiographic Techniques in Forensic Dentistry

Radiography of the mandible and maxilla is often the single most useful tool for making a positive dental identification with reasonable medical

certainty. It is possible, with little extra effort, to X-ray fragments of the mandible or the maxilla, either at the morgue, or on your own bracket table. Careful attention to the placement of a film and the angulation of the central beam will enable the forensic dentist to closely duplicate ante-mortem radiographs. In taking post-mortem radiographs the best results are obtained when the angulation of the X-ray tube in relation to the radiographic film and the part to be examined are the same as for the ante-mortem radiograph.[37] A reduction of kVp and mA.s in the order of 25 - 50% of the normal exposure is usually necessary to compensate for the absence of soft tissues when working with skeletal remains. Standardisation of the techniques of film processing will help the forensic odontologist to obtain radiographs that will provide maximum information. Three common ways of developing films are: (1) by the process of inspection; (2) the time-temperature method and (3) automatic processing. For optimal results the latter two techniques are recommended.

Depending on circumstances, various X-ray machines have been recommended in the radiographic examination of human remains. If the body or parts thereof are moved to a properly equipped post-mortem room or surgery, an ordinary intraoral X-ray unit with a 65 kVp range would be sufficient. In the investigation of a large number of bodies, a miniature radio-active radiographic apparatus has been used for many years.[38] The use of this pencil-shaped iodine 125 unit is now prohibited and it is no longer produced.

Field equipment include daylight processing films as well as ready-packed intraoral instant processing films and an ordinary dental X-ray tube mounted on a tripod.

Conclusion

Maxillo-facial radiology can be extremely valuable in any forensic investigation. Radiographs are the most important supplement to the clinical recording; they constitute an objective form of registration and contribute a multitude of detail not otherwise observable.[39] In some instances a single tooth may be all that remains, and upon comparison of ante-mortem with post-mortem radiographs, a positive identification can be made. Skull and facial bone radiographs are often the only ante-mortem records available and could be of great value in the final identification of an unknown person.

Finally, it is recommended that all radiographs taken during the course of dental practice be adequately processed and kept for as long as possible since there is always a chance that such an ante-mortem record may form part of, if not the only, evidence which will lead to the identification of a deceased person.

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