TITLE

Prevalence Of Tinnitus And Hearing Loss In South African Dentists And An Investigation Into Possible Connections With Noise Levels And Frequencies In the Dental Environment

By

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Declaration

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Signature: Date:

Abstract

An investigation was undertaken to ascertain whether there could be a connection between noise levels in a dental environment and noise induced hearing loss (NIHL) in a sample of South African dentists. This took the form of a questionnaire sent to dentists in the Central Gauteng and Cape Western areas, followed by the measurement of noise emissions of airotor / air-turbine handpieces.

Opsomming

'n Ondersoek is geloods om te bepaal of daar 'n verband bestaan tussen die geraas vlakke in 'n tandheelkundige omgewing en Geraas Geïnduseerde Gehoor Verlies ("Noise Induced Hearing Loss") in 'n groep Suid-Afrikaanse tandartse.

Die ondersoek het bestaan uit 'n vraelys wat tandaartse in Sentraal Gauteng en die Wes Kaap voltooi het, opgevolg deur die meting of registrasie van geraas vlakke veroorsaak deur lugturbine handstukke.

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1. CHAPTER ONE

INTRODUCTION

It has long been hypothesised that there is a relationship between hearing loss (uni- or bilateral), tinnitus, hyperacusis and noise (Axelsson A & Sandh A 1985).

Naturally one or all of the above may have other aetiological factors that are discussed in this thesis.

1.1 PURPOSE OF THE INVESTIGATION

1.1.1 The purpose of the investigation was to try and determine a possible cause-and-effect relationship between noise levels and frequencies, found in a working South African dental environment, and noise induced hearing loss (NIHL) in a segment of the South African dental population.

1.1.2 The author set out to try and link a possible relationship between hearing problems and noises in the dental surgery, (particularly high-speed type drills), amongst a (major) portion of the dental population in South Africa.

2. CHAPTER TWO

LITERATURE REVIEW

A widespread examination of the relevant literature was undertaken to see whether any other in-depth research projects have been undertaken linking noise to NIHL, and whether hearing loss, tinnitus and/or hyperacusis were involved singly or in combination. A literature study was also done on tinnitus – be it noise induced or due to other aetiological factors.

2.1 ANATOMICAL ASPECTS

THE INNER EAR AND ANATOMICAL DETAIL OF THE ORGAN OF CORTI

2.1.1 The Inner Ear

The inner ear, or labyrinth, lies in the temporal bone. It can be described as being divided into a bony and membranous portion.

The bony labyrinth consists of a thin, but dense, bony shell surrounding the vestibule and the semi-circular canals, which make up the vestibular part; and the cochlea.

The membranous labyrinth contains the sensory epithelium of the cochlea and vestibular structures, and lies within cavities surrounded by the bony labyrinth. In addition to containing the membranous labyrinth, the bony labyrinth is filled with perilymph. The exact origin of this fluid is not known, although it resembles plasma, interstitial fluid and cerebrospinal fluid in its make-up with major differences being the concentration and type of proteins present.

The vestibule and semicircular canals are concerned with bodily equilibrium while the cochlea facilitates hearing.

2.1.1.1 The Cochlea

The bony cochlea lies in front of the vestibule and has an external appearance similar to the shell of a snail. It is a spiral organ or coiled tube, with the inside of one coil being separated from the lumen of an adjacent coil by a dense, but thin bony wall. The shell has approximately two-and-a-half turns, and would be about 3.8cm long if straightened out.

The coils of the cochlea turn about a central cone or modiolus which arises from the cochlear nerve portion of the fundus of the internal auditory meatus, and points laterally and forwards, tapering from a wide base to a narrow apex. The apex of the cochlea therefore faces towards the upper part of the medial wall of the tympanic cavity, while the basal coil forms the bulge of the promontory below this.

Arising from the modiolus is a thin shelf of bone that spirals upwards within the lumen of the cochlea as the bony spiral lamina. A membrane - the membranous spiral lamina, which extends from the edge of the bony spiral lamina to the outerwall of the cochlea - divides the cochlea into vestibular and tympanic canals, which connect at the tip of the cochlea and contain a fluid called perilymph. There is communication between the perilymph spaces each side of the spiral lamina and this channel is called the helicotrema.

Around the base of the hair cells are the ends of the auditory nerve fibres, which run inward towards the axis of the cochlea spiral to form the auditory nerve. This sensory portion of the inner ear is bathed in a separate fluid, the endolymph, which is situated in the cochlea duct. Endolymph is kept from mingling with the perilymph by a thin membrane, called Reissner's membrane. Reissner's membrane is a thin membrane stretching from the bony spiral lamina to the upper part of lateral wall of the cochlear duct. (Scott-Brown etc 1997) (See illustration p64).

The endolymphatic and perilymphatic spaces extend along the inner ear. The perilymphatic space surrounds the membranous labyrinth and opens into the CSF by way of the cochlear aqueduct. The endolymphatic space, as well as continuing throughout the membranous labyrinth, is joined to the endolymphatic sac by means of the endolymphatic duct.

2.1.1.1.1 The cochlea duct (scala media)

The duct of the cochlea consists of a spirally arranged tube lying on the upper surface of the spiral lamina against the outer wall of the bony canal of the cochlea.

2.1.1.1.2 The floor of the cochlea duct

The inner part of the floor is formed by the bony spiral lamina which separates into two ridges one above the other. The upper ridge is the spiral limbus from which the tectorial membrane originates, while the lower ridge gives rise to the membranous spiral lamina and has acoustic nerve fibres running through it to the organ of Corti in which the auditory receptor cells and the hair cells (outer hair cells (OHC), inner hair cells (IHC) and Stereocilia) are embedded.

2.1.1.2 Cochlea Mechanics

The mechanical travelling wave in the cochlea forms the basis of the frequency selectivity of the whole organism and, in addition, is the basis of our extreme sensitivity to sounds. A normal travelling wave is fundamental to normal auditory function, and a pathological wave, as probably happens in most cases of cochlear sensorineural hearing loss, can cause a severe deficit.

The auditory cortex is situated in the lateral or Sylvian fissure in primates. The core area, which is the primary auditory cortex, receives its input from the ventral division of the medial geniculate body.

The cochlear nucleus receives branches of the olivocochlear bundle and other centrifugal fibres from the superior olivary complex and from higher auditory nuclei including the nuclei of the lateral lemniscus and the inferior colliculus. The centrifugal fibres are both inhibitory and excitatory.

The centrifugal or efferent pathways are parallel to the afferent pathways along the entire length of the system from the cortex down to the hair cells. At many points along the auditory pathway, they run adjacent to the tracts and nuclei principally associated with the ascending system. The descending pathways are thought to perform some sort of control function but the details are not well known.

One component of the bundle (the medial olivocochlear system), which arises from the medial borders of the superior olivary complex and projects mainly contra-laterally, innervates the outer hair cells directly. A smaller number of fibres, making the lateral olivocochlear system, arise laterally in the superior olivary complex, mainly on the ipsilateral side and innervate the afferent dendrites below the inner hair cells. (Guinan, Warr and Norris, 1983)

The olivocochlear bundle may reduce the auditory input when the subject is attending to stimuli in another modality. The olivocochlear bundle also seems to affect auditory discrimination in the presence of noise.

2.1.1.2.1 The responses of auditory nerve fibres and the activation of nerve fibres

Neurotransmitter is released in the synapses at the base of inner hair cells and this gives rise to action potentials in the auditory nerve fibres. Single auditory stimuli are always excitatory, never inhibitory (Attias, Pratt 1985).

2.1.1.2.2 Basilar membrane vibration and auditory nerve responses in pathological cochleae.

As studied physiologically, it is apparent that most types of cochlear sensorineural hearing loss are related to loss of the sharply tuned portion of the mechanical travelling wave. This has been seen directly in the travelling wave, in the responses of hair cells and in the responses of auditory nerve fibres. The loss probably happens because outer hair cells are among the most vulnerable elements in the organ of Corti, leading to the loss of their contribution to the active mechanical component of the travelling wave. Moreover, it is likely that small deteriorations in the outer hair cell travelling wave system are immediately noticeable. In the more severe cases, the loss of inner hair cells and auditory nerve fibre responses will also reduce the detection of sounds (Bohe et al. 1987).

2.1.2 Anatomical Details Of Organ Of Corti (According to Feldman and Shulman)

The outer hair cells (OHC) of Organs of Corti (about 15 000 altogether) are arranged in 3 rows (Shulman 1997). Each cell carries about 100 – 120 stereocilia, which differ in length. The longest steriocilia of the OHC are firmly connected to the tectorial membrane. The OHC are able to perform tonic contractions as well as very fast oscillating contractions.

The inner hair cells (IHC – about 5 000) are arranged in one row. Each cell has about 60 stereocilia, which normally do not contact the tectorial membrane. IHC do not have the capability of active motion.

The IHC and OHC are connected to the central auditory pathways by two systems. Afferent fibres starting from the bipolar cells in the ganglion lead to the cochlea nuclei in the brainstem, ipsilaterally and contralaterally. Efferent fibres reach the cochlea via the oliva-cochlear bundle.

Although the OHC outnumber the IHC by a ratio of 3 to 1, it is the inner ear hair cells that are exclusively connected to the afferent system: 90-95% of the afferent fibres arise from the IHC. About 20 – 30 unbranched fibres are attached to each IHC. The OHC are connected to only 5 – 10% of the afferent fibres, each fibre serving a bunch of OHC along the basilar membrane at a length of 0,6 to 1mm.

This means that information transferred from the cochlea to the central pathways almost exclusively comes from IHC. The OHC, on the other hand, have a very rich efferent innervation with enormous synaptic contact areas between nerve endings and hair cells (Feldmann 1995).

2.1.3 Morphology of Hair Cells and the Organ of Corti (According to Zenner) (Sataloff & Sataloff, Journal of Occupational Hearing Loss, 1993 [a], [b], [c])

Zenner describes a slightly different, but similar picture to Feldman and Shulman. The Organ of Corti in the inner ear contains approximately 15 000 to 20 000 hair cells, resting on a basilar membrane. These hair cells are arranged in long rows conforming to the spiral shape of the Organ of Corti.

There are approximately 4 000 inner hair cells arranged in a single row and almost 3 to 4 times as many outer hair cells, which run in 3 to 5 parallel rows. There is a tunnel between the inner and outer hair cells. There are also various types of supporting cells in the inner ear that relate to the nerve fibres as well as to the inner ear.

Physiologic models for tinnitus should specify the types of tinnitus to be examined. In the case of cochlear type tinnitus, one must consider inner ear pathology and the recent work of the molecular structure of hair cells, past models of the transduction process and the elements identified and involved; the physiology of the hair cells; the electromechanical properties of the hair cells; cochlear electroanatomy and the cochlear fluids – perilymph and endolymph.

Zenner demonstrated reversible slow and rapid longitudinal movements of the cylindrical body of isolated outer hair cells (OHCs) (Zenner HP 1986). During electrical stimulation, high frequency motile responses were produced. The active role of the sensory hair bundle depends on the motility of the cuticular plate. The OHCs are capable of slow and rapid motile response of the cuticular plate, which displaces the passive stereocillary bundle. This shearing motion of the steriocilia with the tectorial membrane is considered a second motile mechanism that can enable sensitivity and sharpen tuning in the cochlea.

The reversible longitudinal hair cell contraction induces an abnormal change in the cochlea mechanism, resulting in hearing loss and tinnitus. Zenner has investigated the molecular basis of hearing and hearing disorders located in sensory cells. The disease process is related to a) calcium channels in the apical part of the hair cell, b) the influence of potassium on the hair cell and the identification of actin and myosin in the hair cell. The subsequent changes observed in vacuolisation at the basal part of the hair cell present morphologic characteristics, which, when abnormal, may explain a change in the transduction process, of which tinnitus may be a symptom. Appropriate models using such information may provide evidence for the existence of a clinical cochlear type of tinnitus.

Most of the histopathologic changes in the cochlea of aging people as well as other processes that cause cochlear damage (e.g. noise) begin in the basal area or hook region near the round window of the cochlea, and advance toward the upper portions of the cochlea as degeneration continues. Some signs of deterioration also occur in the apex of the cochlea, but to a lesser extent. Why pathological changes first affect the base of the cochlea, regardless of the disease process, is unknown. Deterioration of some or all of the sensorineural components is most pronounced in the base of the cochlea in cases of presbycusis, but also results from other causes e.g. heredity, toxicity including ototoxicity and noise exposure.

Hair cell loss, first of the outer and then the inner hair cells, is most common in older cochleas. There may be a total loss of hair cells in the hook region of the cochlea near the round window and extending into the anterior basal turn, 10 to 13 millimetres from the round window. The number of affected cells decreases gradually until a normal population of cells is apparent in the upper turns of the cochlea. The hair cell loss does not affect hearing significantly until the damage reaches the upper anterior basal turn of the cochlea, about 13 millimetres from the round window, where frequencies of 3000 and 2000 Hertz are perceived.

Other than by location, the hair cell loss found in the temporal bones of individuals with a history of noise exposure cannot be differentiated from the loss seen in bones from the aged.

It appears that the major cause of hearing loss from presbycusis and noise exposure is damage to the Organ of Corti. Presbycusis appears to be largely sensory plus some neural, and noise induced hearing loss appears to be sensorineural.

2.2. PAIN, TINNITUS AND HYPERACUSIS

There is an analogy between chronic tinnitus in the auditory system and chronic intractable pain in the somatosensory system. Tinnitus may be considered the equivalent of pain (Aran and Cazals 1981; Tonndorf 1987; Shulman 1997; Hazell 1979; Hazell 1995).

The similarities between pain and tinnitus are that:

- they are both subjective sensations, and
- they are both continuous events; with time however they may change in quality and/or character.
- in both systems, the alleviation of the pathological sensation may outlast the cessation of the alleviating stimulus, a phenomenon that with reference to tinnitus has been termed "residual inhibition" (Feldmann 1971).

There is no specific system for either the transmission and/or the processing of pain or tinnitus. Pain signals are transmitted along the general somatosensory pathways and tinnitus signals along the auditory pathways. A widely accepted theory now exists on the mechanisms underlying the generation of chronic intractable pain that is based on physiological evidence (Jastreboff, Hazell 1993; Moller 1984, 1997; Tonndorf 1987).

In addition to their afferent sensory fibres, both systems possess an equally well-developed counterpart of efferent fibres that appears to exercise some control on the input into the afferent fibres. In both systems, the afferent, as well as the efferent fibres, make connections with thalamic centres, as do those of all other sensory systems.

At this time it may be applicable to the problem of tinnitus. The "gate control theory" of Melzack and Wall (1965) states that, from the point of input, pain signals travel along two types of afferent fibres. Both of them project into the substantia gelatinosa and to the first central transmission (T) cells. Together they make up the "gate control system". The substantia gelatinosa exerts an inhibitory effect on the T cells by way of the large fibres, tending to hold the gate closed, and a propagating effect by way of the small fibres, tending to hold the gate open. The output of the T cells project onto the "action system", which in turn serves to trigger the pain sensation, provided the gate is open.

Although postulated previously (Aran et al 1977, 1981), Tonndorf (1987) proposed a mechanism of tinnitus based on an analogy with (chronic) pain perception. According to this theory, tinnitus results from an imbalance between the activity of large fibres innervating IHC and small OHC fibres, caused by partial damage to one or both systems. This model was further extended to imitate Melzack's Gate Control theory of pain, arguing the similarity of IHC fibres to somatosensory, large-diameter fibres and OHC fibres to small-diameter, pain related fibres. It remains to be demonstrated that the interaction mediated by the fibres of OHC and IHC occurs in the manner of presynaptic inhibition, as required in Melzack and Wall's model.

Pain and tinnitus have many similarities, and clearly many major differences. Further explorations of their similarities will likely lead to the development of better tinnitus treatments (Moller 1997).

According to the specificity theory of pain, nociceptors are specialised neurons that are responsible for the detection of pain (Merskey 1980). Alternatively, the pattern theory proposes that pain results from stimulation of multiple classes of sensory neurons, not necessarily from the stimulation of nociceptors (Merskey 1979). The effect of this stimulation is to disinhibit, or unmask, ascending polymodal nociceptive channels. According to this theory, noxious stimuli may not be necessary for the perception of pain. The pattern of the stimulus creates a pain sensation, rather than a pathological entity. This mechanism may be one explanation for chronic pain, because innocuous stimuli can be perceived as painful (Craig, Reiman, Bushnell 1996; Hargreaves 1999).

2.2.1 PROFILES OF HEARING LOSS, TINNITUS & HYPERACUSIS

2.2.1.1 NOISE INDUCED HEARING LOSS (NIHL)

NIHL is a syndrome caused by loud, usually constant noise, and consists of **hearing loss** (mono- or bilateral), **tinnitus** and **hyperacusis**. All three symptoms do not always occur simultaneously, or in the same patient (Hazell, Sheldrake 1991; Pitman, Wiley 1981; Northern, Zarnock 1979; Lorraine 1995).

2.2.2 HEARING LOSS

Hearing loss caused by a lesion in the inner ear is called sensorineural. If air and bone conduction thresholds are increased equally, the hearing loss is sensorineural (Sataloff & Sataloff 1998).

Tuning forks with a frequency of 256, 512, 1024 and 2048 are used to test hearing loss. The Weber tuning fork test is used by placing the stem of a vibrating fork in the midline of the head and the patient indicates in which ear the tone is heard. A patient with unilateral conductive hearing loss hears the tone louder in the affected ear. The reason for this is that external background noise is excluded, and the sound travels faster to that cochlea, resulting in a saturation of a louder noise on that side. By contrast, a patient with sensorineural loss hears the tone in the unaffected ear because the tuning fork stimulates both inner ears equally and the patient perceives the stimulus with the more sensitive, unaffected ear organ (Organ of Corti) and eighth nerve (Handbook of Acoustics 1994; The Merck Manual 1992).

An audiometer is used to quantitate hearing loss. Hearing for each ear is measured from 125 to 8 000 Hertz by air conduction. Hearing loss is measured in decibels (dB) which equals ten times the logarithm of the ratio of the acoustic power of a stimulus required to achieve hearing threshold in a patient to the acoustic power required to achieve threshold in a person with normal hearing. Test results are plotted on graphs called audiograms (Beraneck 1994; Coles and Hoare 1985; Sataloff & Sataloff 1993, 1998; Robinson 1985).

2.2.3 TINNITUS

Tinnitus is the perception of sound in the absence of acoustic stimuli or when there is no external stimulation. Tinnitus is a subjective sensation or experience of the patient (Hazell 1995; Shulman 1997; Jastreboff 1990).

Tinnitus may be a buzzing, ringing, roaring, whistling or hissing sound quality or may involve more complex sounds that occur over time. Some patients describe only one sound, while others describe more than one sound i.e. crickets, cicadas, sine wave. These sounds may be intermittent, continuous or pulsative. An associated hearing loss is usually present.

Tinnitus may occur as a symptom of nearly all ear disorders resulting from:

- Obstruction of the external auditory meatus as a result of blockage e.g. wax, cerumen
- Infective processes (external otitis, myringitis, otitis media, labyrynthitis, petrositis, syphilis, meningitis)
- Eustachian tube blockage (obstruction)
- Otosclerosis
- Middle ear neoplasms
- Meniere's
- Ototoxicity due to salicylates, quinine, aminoglycosides e.g. Gentamicin, neomycin, streptomycin, vancomycin, kanamycin etc., diuretics, heavy metals, alcohol, caffeine, marijuana
- Cardiovascular disease e.g. hypertension, arteriosclerosis, aneurysms
- Anaemia
- Hypothyroidism
- Hereditary sensorineural

- NIHL - Including exposure to very loud sounds e.g. shooting, chain saws, rock concerts, a Walkman, underground blasting (in mining in South Africa). One very loud blast is enough to cause irreversible damage. (Merck Manual 1992)
- Acoustic trauma (blast injury)
- Head trauma
- Pressure or neuritis of the auditory apparatus; brain tumour; eighth nerve tumour, aneurysm
- Otitis media; acute, chronic, suppurative, nonsuppurative
- Otitis interna; acute, chronic
- Dental pathology: malocclusion, malfunction of temporo-mandibular joint
- Intoxication-systemic; gastrointestinal foci of infection
- Allergy
- Trauma: acoustic, acute
- Trauma: acoustic, chronic
- Cervical constriction
- Otic herpes
- Bell's Palsy
- Foreign body trauma to the ear

(Axelsson 1991).

As a causative factor continuous noise is more likely than impulse noise to cause tinnitus. The damage done is related to length of exposure and loudness (Jastreboff 1990 [a], [b], [c]).

With respect to auditory neuroscience, tinnitus offers the challenging question of how relatively weak, continuous signals are being discriminated from the background of spontaneous activity without undergoing habituation. Although tinnitus is strictly a subjective symptom, it is known that it can result from high frequency sensorineural hearing loss from presbycusis and/or NIHL (Attias, Bresloff, Furman 1996 [b]).

Tinnitus resembles phantom somatosensory and phantom pain perceptions. It is important to stress that tinnitus is a physiological disorder of the auditory system, not a psychological or psychiatric disorder (Jastreboff 1990). Analysis of the psychological profile of tinnitus patients reveals the incidence of depression, which may be due to tinnitus, but the general psychosomatic profile remains normal (Budd, Pugh 1996).

The majority of tinnitus cases are related to cochlea dysfunction. The Organ of Corti represents a very complex and delicately balanced micromechanical system. The OHC play an essential role in the frequency selectivity of the basilar membrane. The rigid coupling of cilia to hair cells is crucial for normal hearing function (Clark et al. 1987; Deol et al. 1979).

In 1980, Tonndorf suggested that the basis for the origin of tinnitus might be an alteration in the mechanical coupling between hair cells and the tectorial membrane (Tonndorf J 1980).

Accumulated data shows that a traumatic agent such as noise, causes cochlea damage - starting its degenerative action on the basal high frequency part of the basilar membrane, with OHC affected first, followed by damage to IHC.

Exposure to intense sound first results in bending of the OHC stereocilia, effectively decoupling them from the tectorial membrane and preventing sound-induced excitation of the OHC. Provided the noise is not too intense and does not cause permanent threshold shift, the stereocilia return to their normal state within hours or days. Permanent damage of OHC might result in permanent tinnitus, provided that there are still some functional IHC in the area.

When there is damage to a group of OHC and/or IHC, there is a decrease in auditory information from this region. This may result in a localised reduced efferent discharge rate. Since efferent innervation is diffuse, the ensuing disinhibition would affect normal undamaged hair cells adjacent to the damaged area, resulting in an increase of negative overdampening. The effect may be enhanced by higher centres (cortex), with the overall result being the perception of tinnitus (Zenner 1987).

2.2.3.1 Perception Of Tinnitus

Tinnitus has been described as generating in the cochlea, undergoing pattern recognition within the auditory pathway, and being reinforced by processing within subcortical centres (Tonndorf 1991[c]; Tonndorf 1997; Zenner 1987).

Tinnitus is not a single, well-defined disease. It is a symptom of many pathologies – several types of tinnitus may coexist in one patient (Merck Manual 1992). This approach implies that tinnitus should not be simply categorised into peripheral and central, but that all levels are involved in each case to varying degrees. However, dominance of a given anatomical level may exist (Yoo et al. 1991).

Association cortices, the limbic system, and prefrontal cortex are involved in tinnitus perception (Sataloff & Sataloff 1998). Signal recognition and classification networks - which through plastic modification (especially in the cortex) are able to change the recognition of a pattern of neuronal activity - are assumed to be involved in tinnitus perception (Shulman 1997 [a]).

2.2.3.2 The Stress of Tinnitus

People differ greatly in their response to stress. A tolerable stress level for one person may be an intolerable stress level for another. The stress from tinnitus is that one's body reacts as though it is constantly being threatened. If this situation exceeds the capacity for coping, an abnormal psychological and/or physiological state can result.

A substantial number of the tinnitus clinic patients report that their tinnitus seems "louder" when they are experiencing fatigue or stress. It is not clear whether such reports reflect actual changes in the tinnitus sensations or whether they represent reduced tolerance on the part of the individuals involved (Meikle & Griest 1991; Hallam et al. 1984). In these circumstances tinnitus can interfere seriously with the ability to lead a normal life.

Even tinnitus that is perceived as a soft sound (i.e. 50 – 56 dB) can induce an enormously high level of annoyance (Tinnitus Today 1998; Jastreboff 1995 [a]).

Comments noted by tinnitus sufferers when they perceive the noises for the first time, have included: "Perhaps I have a brain tumour"; "Maybe I'm going crazy"; "I will not be able to tolerate this"; "I will not be able to work"; "I might lose my job because I will not be able to concentrate"; "I can't stand this noise in my ears one more minute!" (Jastreboff 1995 [b]).

Unfortunately, many tinnitus patients have admitted that initial encounters with health care professionals, further enhance these thoughts and beliefs, rather than being helpful. For example, patients are commonly told, "It may last forever. There is nothing that can be done about it. However, we must do a brain scan to rule out a brain tumour" (Axelsson 1989).

If someone is afraid that tinnitus is an indication of another medical problem, this tells the brain that the tinnitus signal is important and should be followed up and monitored, in much the same way as pain perception can be an important warning of a disease process (Meikle, Vernon, Johnson 1984).

So the perception of tinnitus for the individual is enhanced and the tinnitus related sound activity is detected all the time. Once this happens, it causes more annoyance, prevents enjoyment of recreational pursuits, and makes concentration and sleeping more difficult (Meikle, Walsh 1984).

Sleep is particularly relevant to tinnitus sufferers because tinnitus tends to be more noticeable in the quiet. The noise of tinnitus is in sharp contrast to the silence and is therefore perceived more loudly and clearly (Penner 1982; Penner 1986; Von Wedel et al 1991; Altser et al 1993).

Any additional stress or annoyance increases the brain's focus on the tinnitus related activity. Because the brain perceives it as a very important signal, its perception is further enhanced. Although the perception of tinnitus has an enormously strong effect on people and can be absolutely devastating, it does not typically indicate that there is anything wrong happening within the auditory system. Actually, it usually indicates over-compensation of the auditory pathways in response to small and otherwise insignificant distortion in the inner ear (Moller 1995).

2.2.3.3 Five Stages of Tinnitus

(As described in The American Tinnitus Association Brochure 1985)

- Tinnitus is present but spontaneous and transient – and is usually ignored.
- Tinnitus is irritating but can be ignored. Does not interfere with work or social activities.
- Tinnitus is always present and usually difficult to ignore, but with effort one can maintain work and other activities.
- Tinnitus is always present and distressing – makes it difficult to concentrate.
- Tinnitus is always present and is an overwhelming problem most or all of the time. Patients are unable to perform work adequately and it interferes totally with social activities (Shulman 1991 [a]).

Tinnitus is a neurophysiological phenomenon, and is very real for those that experience the symptoms (Jastreboff 1995 [c]).

Results show that tinnitus is a very common experience. In the U.S.A. approximately 44 million people suffer from tinnitus. It is estimated that 12 million people suffer from stages 4 and 5 – five million people suffer from stage 4, and 7 million sufferers are of stage 5. The American Tinnitus Association (ATA) estimates that approximately 12 million Americans have tinnitus severe enough that their quality of life is negatively compromised. It creates a problem sufficiently serious that they seek medical professional help (Gullikson 1978).

In the U.K. approximately 360 000 suffer from tinnitus, of which approximately 80 000 seek professional help (Davies 1995). Typically, medical professionals are not eager to deal with the problem of tinnitus, and tend to recommend that patients "learn to live with it" (Vesterager 1997).

2.2.3.4 What It Is Like To Have Tinnitus

For most tinnitus sufferers, the symptoms are annoying but not intrusive (Shulman 1991 [b]). For most, having tinnitus is just a nuisance. In its severe form, tinnitus can be a chronic condition causing loss of concentration, abnormal sleep patterns and psychological distress. There is usually an associated hearing problem that will be exacerbated by tinnitus. According to Shulman (1991 [b]), Tinnitus is described as the third worst medical condition that can happen to humankind, following 1) severe, intractable, unrelievable pain; 2) severe, unrelievable dizziness (Brenner 1981; Coles, Hallam 1987).

2.2.3.5 How Tinnitus Affects One

Tinnitus is exacerbated whenever one is exposed to noise. Because of hyperacusis (hypersensitivity to noise), tinnitus sufferers can no longer attend functions such as concerts, dances, parties etc. Sufferers need to avoid use of trucks, buses, sports cars, motorbikes, etc. One may not be able to use lawnmowers, chain saws, vacuum cleaners, food processors, firearms and electrical tools. Even the loud bark of a dog can be intolerable. Some tinnitus sufferers have had to quit or change jobs because of work related noise (Goodwin & Johnson 1980; Hulshof 1986).

2.2.3.6 Tinnitus In Normal Hearing Persons

The ability in individuals with normal hearing to detect tinnitus rises to 94% when placed in a soundproof room for up to 5 minutes. The sounds perceived by such individuals are identical to those perceived by individuals complaining of tinnitus distress. (Heller 1953)

Coles (1984 [a]) documented that 10% of adults at some time have experienced tinnitus for more than five minutes, not associated with noise exposure. Four percent complained of tinnitus causing mild to severe annoyance. The general incidence of tinnitus in people exposed to noise is also much higher i.e. 23%. (Coles 1984 [b]) This in itself indicates a two-fold chance of developing tinnitus when compared to people not exposed to noise.

2.2.4 HYPERACUSIS

Most patients and many health care professionals describe hyperacusis as "exceptionally sensitive hearing ability" or "hypersensitivity to sound". In Dorlands Medical Dictionary (26th edition) hyperacusis is defined as "an exceptionally acute sense of hearing, the hearing threshold being unusually low It may or may not be accompanied by pain".

Hyperacusis is best defined as "the collapse of loudness tolerance" to normal environmental sounds, so that almost all sounds are uncomfortably loud, even though the actual sound intensity is well below that judged to be uncomfortable by others (Hazell & Sheldrake 1992).

This is because with hyperacusis, ears lose most of the dynamic hearing range. Dynamic range is defined as the ability of the ear to deal with quick shifts in sound loudness i.e. decibel levels.

Hyperacusis does not increase hearing sensitivity i.e. acuity. Many hyperacusis patients actually display hearing impairment. The hyperacusis patient experiences a great deal of discomfort and for that reason they seek quiet and protected areas.

Hyperacusis differs from **recruitment**, which is an abnormal growth in the perception of loudness accompanied with hearing loss. With recruitment, loud noises are uncomfortable. With hyperacusis all sounds are too loud.

The disorder is often chronic and is usually accompanied by tinnitus, but can occur in patients who have little hearing loss.

Noise exposure generally makes the condition worse and exacerbates the accompanying tinnitus. There is speculation that the **efferent portion of the auditory nerve has been affected.** The only factor known that unquestionably affects progression or regression is continued exposure to loud noise.

In a survey conducted by ATA, of 1112 patients with both tinnitus and hyperacusis, 53% listed hyperacusis as worse than their tinnitus, while 25% listed both problems as equally disturbing, leaving 16% who placed tinnitus as the worst and 6% as unsure (Tinnitus Today, March 1999; American Tinnitus Assoc 2002).

2.2.4.1 What It Is Like To Have Hyperacusis

Imagine being at a movie where the soundtrack is turned on to the highest volume. Actors' voices are screaming at you. In much the same way, turning newspaper pages, running water in the sink, eating in a noisy restaurant are all intolerable to your ears. A baby's cries, or a truck screeching its breaks to a halt, are excruciating sounds.

A person who lives with hyperacusis cannot simply get up and walk away from noise. Every day sounds sound unbearably or painfully loud. Instead the volume button of the whole world seems to be stuck on high.

Hyperacusis can be devastating to the sufferer's career, relationship and peace of mind. It makes living in the noisy 20/21st Century difficult and dramatically changes the patient's pattern of life. Communicating with others is challenging

(Coles and Hoare 1985; Kilpatrick 1981; Gabriels 1995; Goldstein & Shulman 1996).

Activities that most people take for granted such as driving a car, walking down a busy street, listening to the TV, stereo, speaking on a telephone, shopping, attending events, dining at restaurants or participating in group activities often are difficult or impossible.

2.3 NOISE

Our sensory system affects the way we exist in the environment in which we live. These systems can protect us from, and help us enjoy our environment. Each of our senses is bombarded by stimuli of various sorts. These stimuli can elicit responses ranging from pleasure to pain and can produce physiological and psychological damage when either absent or carried to extremes.

The stimulus perceived by the sense of hearing is referred to as sound; disagreeable sounds are known as noise.

Noise is defined as unwanted sound. It varies in terms of frequency, intensity and duration e.g. loud rock music is enjoyable to some while others find it offensive and objectionable. Thus for a sound to be categorised as a noise, it must be judged as such by the listener (Tempest 1985).

> *"What kind of noise annoys an oyster?*
> *A noisy noise annoys an oyster."*
> *Unknown*

Many sounds in our environment that we classify as noise are annoying, but not loud enough to cause damage to our hearing. Other sounds are of such intensity that they are dangerous to the ear. Continuous exposure to high levels of noise can cause permanent hearing impairment and/or tinnitus in some individuals (Coles et al. 1985; Acton 1983, Attias, Urbach et al. 1993; Bauer et al. 1991).

Susceptibility and reaction to noise varies considerably from person to person. In the United States it has been postulated that most people will not experience hearing loss if noise levels do not exceed 85dB (Ward, 1980). The Occupational and Safety Health Act (OSHA) in the United States established criteria in the workplace of an eight-hour duration at 85dB of continuous noise. There are no published noise levels that are known to specifically induce tinnitus. Note: dB (decibel level) is logarithmic, not exponential. Hence 100 times more sound energy enters the ear in a 95dB environment than in a 75dB environment.

Typical hearing loss observed in patients who have a long history of on-the-job exposure to noise, is characterised by a hearing loss in the frequency range of 3 000 – 6 000 Hertz. Continuous exposure to noise will result in a permanent hearing loss that is progressive in nature and becomes subjectively noticeable to the patient. These changes can be measured by an audiogram (Acton 1974; Burns & Robinson 1970).

Noise is the most probable cause of tinnitus. It has been noted that many patients with hearing loss do not have tinnitus, but most tinnitus sufferers have hearing loss (Shulman 1991 [b]; Feldmann 1995; Sataloff & Sataloff 1998). Most patients who have a long history of noise exposure complain of tinnitus that is tonal in quality and high pitched. Most patients matched their tinnitus to external tones above 3000 Hertz (Marion & Cevette 1991; Rahko, Karma, Kataja 1988; Vernon 1979; Coles & Hoare 1985).

2.4 DRILLS, NOISE AND FREQUENCIES

A high-pitched, whining noise can be most annoying even when it occurs infrequently, for example a mosquito. It is not surprising then that since the advent of high-speed dental drills, dentists have complained about the noise to which they are exposed during a typical working day. Because most of the sound energy from these drills lies in the high frequency range (above 4 000 cycles per second), the noise is indeed irritating and piercing. Park voiced concern that constant exposure to this noise may be dangerous to the dentist's hearing (Park 1978).

The intensity of the whine from drills in common usage reaches 85 to 90dB, which was specified as "dangerous and hazardous" by damage-risk criterion for steady eight-hour exposure (Stanford, Fan, Stanford 1987). Typical results of sound-level measurements conducted with Sandri and Borden handpieces, by Taylor, Pearson and Mair in 1965, found levels of above 85dB for a ball bearing type of drill at or near the dentist's ear.

Air bearing drills, as opposed to turbines, are supposedly safer, because they have levels some 10dB lower. This is true only for instruments in good condition. Smith and Cole (1966) reported that a defective drill resulted in a level of 90 to 95 dB at 8 000Hz. At that time, the majority of studies indicated that only a small amount of hearing loss may be produced by exposure to high-speed drill noise, and that this requires several years to become measurable. However, many dentists believe that high-speed drills are a very real hazard (Ward and Holmberg - 1969).

In a later article (reports on Councils and Bureaus/JADA, Vol 89, Dec 1974), it was reported that sound analysis studies reported on frequencies of handpieces of all manufacturers up to that time. Early models of handpieces recorded ranges up to 8 000Hz. Improved design in ball bearing-models, introduction of airbearings and improved exhaust systems have reduced frequencies to the 2 000 to 6 000Hz range.

Potential hazards exist in frequencies of 10 000Hz and above (Roberts 1978). It must be recognised that the sound analysis studies were carried out under ideal conditions with new equipment operating at optimum rotation speeds. Handpiece wear, bur concentricity, misuse, poor maintenance, and individual surgery design (walls and ceilings which can absorb sound) can influence the frequencies from individual handpieces (Cantwell et al. 1965).

Decibel readings are influenced by the aforementioned conditions – new free running roller bearing handpieces at recommended air pressures recorded 68 to 97 dB readings. Handpiece manufacturer Midwest reported the recordings for air-bearing handpieces to be approximately 10dB lower. Additional conditions that vary the recordings are the distance and position of the handpiece in relation to the recording device. Accepted decibel ratings are: safe range – 0 to 70dB; moderate to high-risk range – 80 to 100dB. The report by Taylor, Pearson and Mair (1965) stated that when practitioners were exposed to drill noise on an average of 3.7 years, a significant noise-induced threshold change was sustained in the higher frequencies range (4 000 to 6 000Hz).

Short, loud noise periods can result in loss of some hearing sensitivity, a phenomenon called temporary threshold shift (Shulman 1997 [a]). If there are sufficient rest periods between exposures, recovery will be complete (Shulman 1997). This will affect individuals differently in relation to their personal susceptibility. It has been postulated that the temporary shift over a long time can become permanent (Shulman 1997 [d]; Coles, Hoare 1985).

2.4.1 Mechanics of Sound Transmission

Sound travels in waves, like the ripples created when a pebble is dropped in a body of water.

2.4.1.1 Intensity and Frequency

A given sound has both intensity and frequency. The **intensity** is measured on a logarithmic scale using decibels (dB). That is to say that a sound of 10 dB is 10 times greater than zero dB, whereas a sound of 20 dB has 100 times the intensity of zero dB. In physical terms, dB equals 10 times the log. of the ratio of the acoustic power of a stimulus required to achieve hearing threshold in a patient with normal hearing. Test results are plotted on graphs called audiographs (American Tinnitus Association Brochure 1985).

A sound at zero dB is at the threshold of hearing, whereas a sound of 140 dB is at the threshold of pain (Handbook of Acoustics 1994).

The **frequency** (pitch) of a sound is measured in Hertz (Hz). This measurement is relative to the number of vibrations or cycles the sound source or its wave makes per second (Handbook of Acoustics). The brain is able to recognise through the normal ear, a range of sounds from 20 through to 20 000 Hz (Handbook of Acoustics).

Knowing the intensity and frequency of a sound as it is emitted from its source is a necessary tool for considering the potential health risk.

2.5 OCCUPATIONAL HEARING LOSS

Basic Concepts

A sensorineural hearing loss resulting from noise exposure is known as noise induced hearing loss (NIHL).

It is identified in two forms (Griest S 1995):

1. Acoustic trauma which is a sudden change in hearing resulting from a single exposure to a high intensity sound, such as an explosive blast, gunshot, sonic boom, or industrial explosion.
2. An occupational hearing loss resulting from long-term exposure to loud noises in a working environment e.g. factories, mines etc i.e. industrial noise. It is a chronic, progressive process.

Occupational hearing loss is influenced by the characteristics of the noise i.e. intensity, frequency and spectrum of sound; duration of exposure; and the patients predisposition to develop hearing loss from the effects of noise exposure (Melnick 1986; Shulman 1997 [a]).

In the USA, the Occupation Safety and Health Administration (OSHA) established Federal noise criteria and permissible noise criteria in the workplace (Shulman 1997 [b]).

There are now approximately eight million people with occupational hearing loss (OHL) in American industry. Although classified as a "disease", OHL is actually the cumulative result of repetitive injury to the cochlear hair cells.

According to Shulman, if the diagnosis of NIHL is made clinically by a physician it should include a study of the noise exposure history (1997 [c]).

With NIHL the concern is more with the cumulative, slowly progressive hearing loss resulting from chronic noise exposure as opposed to a traumatic sound (Ward & Holmberg 1969; Shulman 1997 [c]).

The principle characteristics of occupational NIHL are as follows (Shulman A 1997):

- It is always sensorineural, affecting the hair cells in the inner ear.
- It is almost always bilateral.
- It almost never produces a profound hearing loss. Usually, low frequency limits are about 40dB and high frequency limits are about 75dB.
- Previous NIHL does not make the ear more sensitive to future noise exposure.

The earliest damage to the inner ear reflects a loss of 3 000, 4 000 and 6 000 Hertz. The greatest loss usually occurs at 4 000 Hertz (Shulman 1997[c]).

Continuous noise exposure over the years is more damaging than interrupted exposure to noise, which permits the ear to have a rest period.

2.6 COMPARATIVE LITERATURE OF STUDIES IN THE DENTAL OFFICE

The dental office contains a number of devices that produce sounds, such as drills, compressor, suction apparatus, ultrasonic instruments. Of all the sources of sound in a dental surgery only the air-driven, high speed handpiece have been identified as a potential noise hazard (Park 1978).

2.6.1 High Speed Handpiece Noise

Does the high-speed handpiece have a Dr. Jekyl and Mr. Hyde connotation? It permits the dentist to provide an accurate, more efficient service to more patients, while at the same time destroying the dentist's hearing and thus a part of his or her ability to enjoy life. Since the advent of air-driven, high-speed handpieces in the late 1950's, dentists have expressed concern that their hearing acuity was diminishing (Bernier & Knapp 1959).

As soon as dentists began complaining about perceived auditory effects of the new handpieces, researchers began conducting studies (Brenman, Brenman, Erulkar, Ackerman 1960). These studies took into consideration the intensity (dB) of the sound from different types of drills, the frequency (Hz) that they emit and the hearing acuity of dentists. Up to 1978 these studies have been ambivalent - both confirming and denying the existence of a hearing hazard for dentists (Park 1978; Coles and Hoare 1985; A.D.A 1959).

The air-driven, high-speed handpieces have been found to operate in the frequency ranges from 3 900 to 12 500 Hz (and greater). Some of the handpieces are reported to produce ultrahigh frequencies that are beyond the ability of the human ear to hear (greater than 20 000 Hz) and this is believed to cause cochlear damage (Beranek 1994).

Noise induced hearing loss (NIHL) is affected by frequencies above 3000 Hz (American Tinnitus Association Brochure 1985 [a]; Vernon 1995). The intensity of the sound produced by the **air-driven**, high-speed drill has a number of variables. Studies of the earlier **ball-bearing** type of air-turbines showed that they operated at a level 10 dB higher than the more modern air-bearing type. Typical findings for the earlier ball-bearing types ranged from 75 - 94 dB although 1 study (von Krammer 1968) goes as high as 100dB. Findings for the air-bearing drill gave readings from 60 - 80dB. The newer ball-bearing handpieces have been improved to the point where their sound emission has been reduced to the range of the air-bearing types.

The intensity of the sound is found to be greater at the exhaust end of the handpiece than at the head (Park 1978). In most positions of sit-down dentistry, the exhaust is aimed away from the assistant and towards the dentist. For the right-handed dentist the exhaust is closer to the right ear (Park 1978, Smith & Coles 1966).

Probably the simplest solution to noise emission from handpiece systems and which adds no appreciable bulk or weight to the handpiece is the 4-port tubing available with some modern handpieces. The fourth port dissipates the exhaust back into the unit (Park 1978).

2.7 THE EFFECT OF NOISE ON THE DENTIST

Normal aging changes (presbycusis) take place in the hearing apparatus even without exposure to noise. Presbycusis may begin to occur in the 30 – 40 year age groups, and like NIHL, is first experienced in the higher ranges (4 000 Hz and higher).

A study at the College of Dentistry, University of Tennessee, demonstrated that when a group from the faculty were evaluated for anticipated hearing loss due to presbycusis, a significant loss was observed in the noise-induced ranges (4 000 – 8 000 Hz). This study concluded that continued exposure to noise in the dental environment over a number of years would cause a permanent threshold shift (Weatherton, Melton, Burns 1972).

Several studies relating to the possible effect of high-pitched sound on the dentist's hearing acuity also refer to the possibility of psychological and/or physiological effects experienced by the dentist in the dental environment. These include annoyance, emotional problems, nervousness, indigestion, headaches, decreased ability to concentrate, decreased efficiency, and decreased ability to perform complex or multiple tasks. The sound level of most high-speed drills is in the speech interference ranges (especially consonants and sibilants), thus creating difficulty in communication at a normal conversational level (Boggs and Simon, 1968; Crocker and Price, 1975; Imbus, 1976; Forman-Franco et al 1969, 1978; Geld 1965).

One extensive review of the literature, (Miller, Jakimetz 1974) concluded that perhaps the stress of continued exposure to high levels of noise can produce disease or make one more susceptible to disease processes. However, the only conclusively established effect of noise on health is that of noise induced hearing loss (NIHL).

A publication, "Tinnitus and the Dentist", (Gullikson, John 1978), relates to a tinnitus survey that was sent to 600 dentists in four counties in Oregon. 25.3% of the questionnaires were returned. According to the resulting data a significant number of dentists who utilized the air-driven handpiece had ear pathology in the form of tinnitus, hearing loss, hyperacusis or a combination of all three. The 74 dentists who indicated such pathology represented 48.7% of the returned questionnaires.

In the above named study it appears that the prevalence of tinnitus among dentists who utilize the air turbine handpiece is reportedly higher than the prevalence of tinnitus in the general adult population. The comparison continues that even the 17.1% of dentists who reported the presence of severe tinnitus, far exceeds the average population prevalence of 4%. It would appear in relation to this survey that there is a strong probability that the noise and frequency levels of the air handpiece may be a contributing factor of tinnitus in the dental population.

The perception that damage can be done to ears by the high-speed drill began to change several years ago. In an article "Dentist's Hearing: The Effect of High Speed Drill" in the Australian Dental Journal, Aug. 1970 by Skurr and Bulteau, the authors state: "High speed drill noise may not be so innocuous – at least for some ears – as was once thought."

Bernier and Knapp (1959) reported that noise levels in excess of 75dB in frequency ranges of 1 000 – 8 000 Hz may cause hearing damage. Cooperman et al (1965) found that several ultra speed handpieces produced noise levels that bordered on or exceeded dangerous exposure levels.

2.7.1 Consequences of NIHL

According to Coles and Hoare (1985), people with NIHL (who have suffered hearing damaged due to noise), have lost the ability to hear higher frequencies. This results in a considerable loss of intelligibility of sounds, as the sound produced by consonants conveys clearer articulation of speech and therefore comprehension of what is heard. This results is one of the two major complaints of people with NIHL: “I can hear people speaking all right, but can’t understand what they say.” Thus the lack of comprehensible hearing is the primary concern or complaint of NIHL sufferers.

The second major complaint of patients with NIHL is difficulty in understanding what is said when there are other sounds in the background, particularly that of other speech, which too, has great propensity for distracting the listener (Coles and Hoare 1985; Vernon 1977).

The third feature of NIHL is tinnitus. This occurs in about 50% of well-established cases of dentist with NIHL. The very high frequency sounds of high-speed turbine drills, and of ultrasonic scalers, may cause a hearing loss of too high a frequency for it to be noticeable in terms of hearing loss (initially), but could conceivably cause tinnitus (Man, Newman, Assif 1982; George & Kemp 1989 [a],[b]).

For many years tests have been sought which might predict whether an individual is highly susceptible or highly resistant to damage by noise, but without success. Individual susceptibility is almost certainly multi-factorial, with anatomical, biochemical, physiological, pathological and multiple other aspects. In addition the two ears of the same individual may differ quite considerably in susceptibility to noise damage (Shulman 1997[a]).

There is no way of undoing the damage done by noise once it has occurred. The cochlear hairs do not regenerate, and no known successful treatment has been demonstrated to alleviate the condition (Coles & Hoare 1985).

In NIHL, one needs to reduce noise levels, both to prevent further damage as well as to make the existing problem more bearable.

This is exemplified by the change from ball-bearing handpieces to air-driven ones (that took place in the 1960s); and subsequently with the return to the new ball-bearing ones (Park 1978).

2.8 MONITORING NOISE LEVELS IN THE DENTAL ENVIRONMENT

In 1959 the American Dental Association advised dentists to have periodic audiometric examinations. Again in 1974, the American Dental Association, through its Council on Dental Materials and Devices made recommendations concerning hearing conservation amongst dentists. The recommendation was made that each dentist develops a programme to include personal evaluation and noise attenuation.

According to a spokesperson for The South African Dental Association (SADA), Dr N. Campbell in 2001, there are no regulations or specifications for the noise levels of dental handpieces in South Africa. During discussions at the same time with the South African Bureau of Standards, the author was told that there are no regulations regarding industrial noise in South Africa (personal communication.)

According to Sockwell (1971), any dentist who has not had a base-line otologic and audiometric examination to determine his or her current hearing status should have such examinations. Annual tests should be accomplished in order to determine what degree of change has taken place (Sockwell 1971).

According to the author's research, very few dentists have had audiographic testing. Approximately 20 dentists interviewed admitted that although they are not personally aware of hearing loss, they have been told by family members that they are going deaf or are hard of hearing. Very few dentists protect their ears whereas they wear glasses, gloves and masks.

3. CHAPTER THREE

MATERIALS AND METHODS

3.1 THE QUESTIONNAIRE

A questionnaire entitled "**Prevalence of Tinnitus and hearing loss in South African dentists and an investigation into possible connections with nose levels and frequencies**" was sent to one thousand six hundred and one (1601) dentists in the Central Gauteng and Cape Western areas of South African Dental Association (S.A.D.A) (724 to Cape Western and 877 in Central Gauteng). Eighty-four percent (84%) of dentists in South Africa belong to S.A.D.A.

The following questionnaire was used:

"PREVALENCE OF TINNITUS AND HEARING LOSS IN SOUTH AFRICAN DENTISTS AND AN INVESTIGATION INTO POSSIBLE CONNECTIONS WITH NOSE LEVELS AND FREQUENCIES"

1. Age of Dentist: ______________________________
2. Years in Practice: ______________________________
3. Type of Practice:
4. a) General ________ b) Specialist________ Speciality? ____________________
5. Sex : Male ________ Female ________
6. Handpiece used: Airotor________ Air Turbine __________ Ultrasonics ___________
7. Are ears protected whilst using drills? ______________________________
8. Number of hours in practice per day: ______________________________
9. Number of days worked in a week: ______________________________
10. Estimated hours worked with a dental drill in a week: ____________________
11. Symptoms of Tinnitus (ringing in the ears or head noises). If you have Tinnitus or noise induced hearing loss (NIHL) i.e. Tinnitus, Hearing Loss and Hyperacusis, if so:-
    a) When was it first noticed? ______________________________
    b) Is it mild, severe, moderate? ______________________________
    c) Did the problem occur suddenly or over an extended period? ________________
    d) How long have you been aware of the problem? ____________________
    e) Is it unilateral or bilateral? ______________________________
    f) Constant or intermittent? ______________________________
    g) Annoying --- If so, on a subjective scale of 0-10 how would you rate your problem (10 being the maximum)? ______________________________
    h) Is there any sleep disturbance e.g. falling asleep or being woken during the night and possibly not being able to fall asleep again; single or multiple sounds or noises?

       ____
12. Ever necessary to seek medical help e.g. ENT, Otologist, Audiologist? ______________
13. Ever had an Audiogram? ______________________________
14. Need to wear a device e.g. hearing aid and/or masker? ____________________

    If so, did the device help? ______________________________

    Details if possible e.g. successful or failure: ____________________

3.2 HANDPIECE SURVEY

3.2.1 Handpiece survey and measuring the noise levels in a working dental environment.

Studies in the dental environment

The dental surgery contains several pieces of equipments that produce sounds. Of all those that generate sound, it is only the air-driven, high-speed handpiece that has been considered a potential noise hazard (Park 1978; Taylor, Pearson, Mair 1965; Delheim 1971; Sockwell 1971; Coles, Hoare 1985).

For the purpose of this dissertation audiometric tests were undertaken in 32 dental surgeries (including the author's surgery), to measure frequencies and dB levels of air turbines (ball-bearing and air-bearing types), using spectrum analysers and SPL metres and ultrasonic instruments, e.g. Spartan, Piezo electric and Cavitron Scalers.

A number of dB levels were received from hand piece manufacturers (see table). These relate to new handpieces and were measured at the factories under optimum conditions and hence at the lowest (i.e. minimum) dB levels.

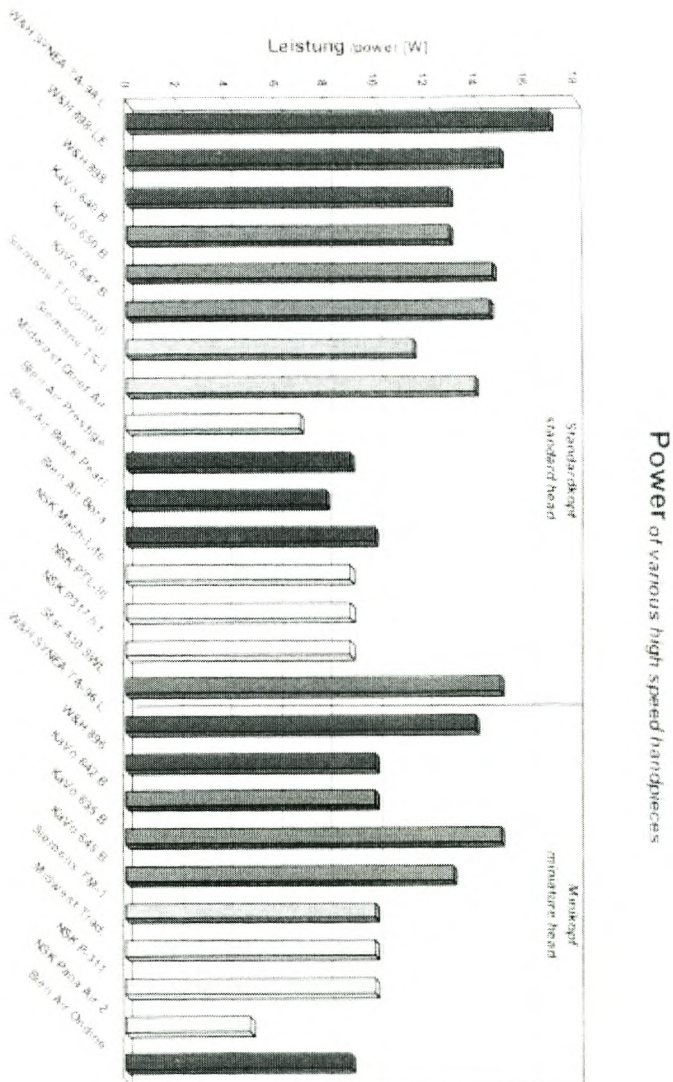
It was found by manufacturers that there is considerable variation of dB level and torque between handpieces of the same manufacturer in the working environment (Park 1978; Ward 1969).

It is important to note that in the working environment, the dB levels will be increased in comparison to the levels stated by the manufacturer, due to the fact that in the laboratory all factors will be ideal i.e. no extraneous sounds, perfect conditions, new handpieces and turbines, perfect conditions.

The dental company Millners Dental Suppliers South Africa also supplied details of all "high speed handpieces sold in South Africa since 1958" (see table). Since about 1995, the newer generation of handpieces have been available in South Africa.

Table 1

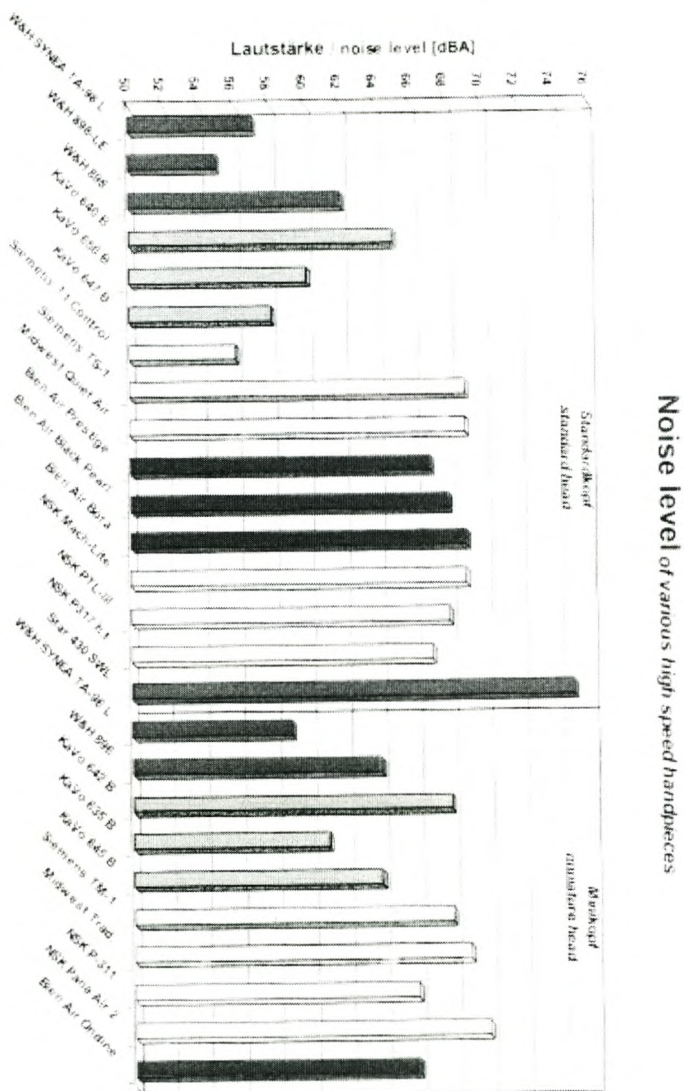
POWER OF VARIOUS HIGH SPEED HANDPIECES



(Millners Dental Suppliers South Africa)

Table 2

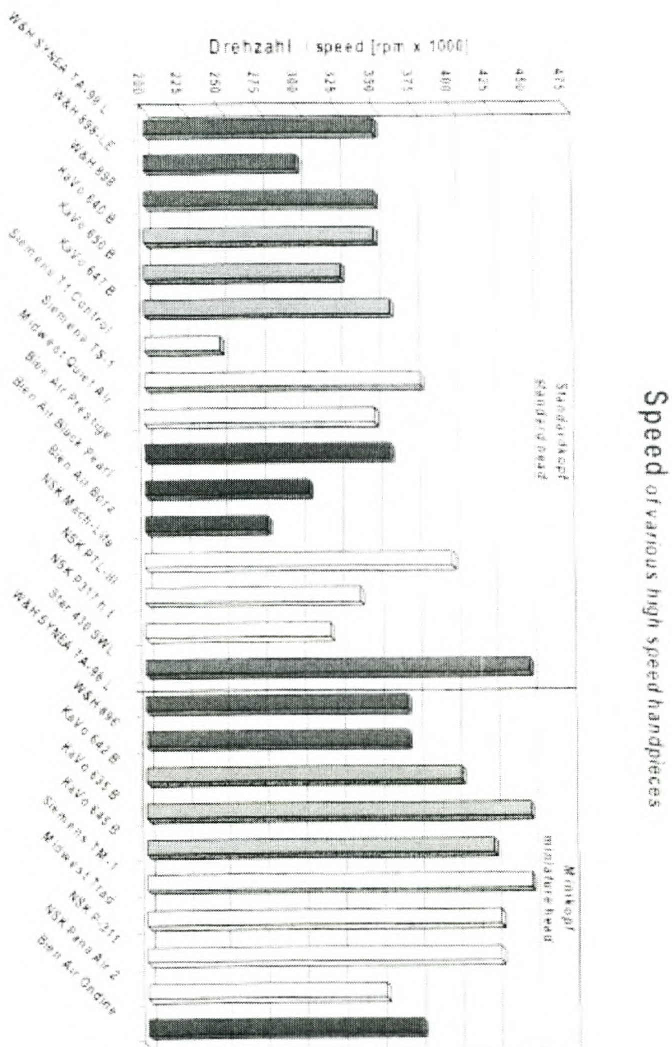
NOISE LEVEL OF VARIOUS HIGH SPEED HANDPIECES



(Millners Dental Suppliers South Africa)

Table 3

SPEED OF VARIOUS HIGH SPEED HANDPIECES



(Millners Dental Suppliers South Africa)

Table 4

HIGH SPEED HANDPIECES SOLD IN SOUTH AFRICA SINCE 1958

Millners

HIGH SPEED HANDPIECES SOLD IN SOUTH AFRICA SINCE 1958

MAKE	TYPE	MANUFACTURER
Borden	Ball-Bearing (Noisy)	Amalgamated Dental now Dentsply, Kavo
Weber	Ball-Bearing (Noisy)	Factory Closed
Sandri	Ball-Bearing (Noisy)	J&S Davis, U.K.
Williams Encore	Air-Bearing (Silent)	Factory Closed
Wispair	Air-Bearing (Silent)	Factory Closed
Kavo	Borden 60 Ball-Bearing	Kavo
Kavo	Borden 68 Ball-Bearing	Kavo
Kavo	All Air Air-Bearing (Silent)	Kavo
Kavo	Super Torque Ball-Bearing	Kavo
Kavo	Bella Torque Miniature Air-Bearing (Silent)	Kavo
Midwest	Ball-Bearing	Now Dentsply
Bien-Air	Ball-Bearing	Switzerland
NSK	Pana-Air Ball-Bearing	Japan
NSK	Phatelus Ball-Bearing	Japan
Lares	Ball-Bearing	USA
W&H	Various	Austria
Siemens	Various	Germany
Faro	Ball-Bearing	Italy

(Millners Dental Suppliers South Africa)

CHAPTER FOUR

RESULTS

4.1 TINNITUS AND NIHL SURVEY

4.2 RESULTS OF QUESTIONNAIRE

According to the S.A.D.A. 84% of dentist in the Republic belong to the Association. 1601 Questionnaires were sent out – 724 to dentists in Cape West and 877 to central Gauteng. 518 Dentists replied and the results have been collated. This represents a response of approximately thirty-five percent (35%), which makes the questionnaire statistically viable according to statistician Dr T vW Kotze, Ph.D., D.Sc.

4.2.1 Tabulated Results of Questionnaire

		Details	Number of Dentists	Tinnitus Details	Percentage
1.		No. of Dentists protecting ears	10		1.93%
2.		No. of Dentists suffering hearing loss	189		36.49%
3.		No. of Dentists suffering from Tinnitus	165		31.85%
	3. 1	Mild Tinnitus sufferers i.e. bothers them up to 30% of the time		100/165	60.61%
	3. 2	Moderate Tinnitus sufferers i.e. bothers them 30% – 60% of the time		43/165	26.06%
	3. 3	Severe Tinnitus sufferers		22/165	13.33%
	3. 4	Sudden awareness of Tinnitus		23/165	13.94%
	3. 5	Extended awareness of Tinnitus		142/165	86.06%
	3. 6	Unilateral Tinnitus		50/165	30.30%
	3. 7	Bilateral Tinnitus		115/165	69.70%
	3. 8	Intermittent Tinnitus		68/165	41.21%
	3. 9	Constant Tinnitus		97/165	58.79%
	3.10	Sleep disturbance sufferers		30/165	18.18%
	3.11	Sought medical help		58/165	35.15%
4.		Had an audiogram	91/518		17.57%
5.		Hearing Loss/ Tinnitus sufferers with hearing aid.	21/165		12.73%
6.		Device helped	16/ 21		76.19%

4.2.2 Summary Of Handpieces Used

In this survey, all dentists used at least two turbine handpieces alternatively and at least 50% rotated five or more handpieces.

The most common makes of handpieces used by the surveyed dentists are: Kavo, NSK, Midwest, W & H, and Siemens.

Two dentists still used the original Borden handpieces (ball-bearing type), which were in reasonable condition, and the dentists assured me that they were serviced "reasonably regularly".

One dentist still used a Sandri, which had incredible torque and was extremely noisy (>100 dB).

All 32 dentists were right-handed, and measurements were made at approximately 23 – 35 cm from the handpieces, when operated at optimum speed of 40 – 60 pounds air pressure. The levels measured between 58 and 104 dB at between 4 000 – 6 000 Hz (c.p.s.).

It is worth noting that in this survey only five of the 32 dentists - two Prosthodontists, two general practitioners and the author (limiting practice to endodontics) - used shottist's earmuffs to protect their ears.

Of the five, one Prosthodontist, one general practitioner and the author suffer from severe NIHL and one general dentist has moderate to severe hearing loss. Unfortunately, all of those persons only started using ear protection once damage had already taken place. The second Prosthodontist has been using NSK handpieces for a number of years and has the turbines replaced every 9 – 12 months. Recently he purchased five new NSK handpieces. The one general dentist with NIHL recently changed to NSK handpieces (X 3).

Interviews with **manufactures of handpieces** provided the following information about their new model handpieces:

KAVO 650B LUX TURBINE

Noise: 65 – 70 dB (free running)

Speed: 350 000 r.p.m.

KAVO 7000B LUX

Noise: 62 dB

Speed: 350 000 r.p.m.

Power: 15 watts

MIDWEST TRADITION

Noise: 72 – 75 dB (free running)

Speed: 425 000 - 450 000 r.p.m. @ 35 p.s.i.

Power: 12 – 13 watts

MIDWEST XGT

Noise: 65 dB

Speed: 300 000 r.p.m.

Power: 14 watts

MIDWEST QUIETAIRE (1998)

Noise: 68 – 72 dB

Speed: 350 000 - 400 000 r.p.m.

W & H SYNEA

Noise: 62 – 65 dB (free running)

Power: 13 watts

W & H TOPAIR

Noise: 62 dB (free running)

Speed: 300 000 – 325 000 r.p.m. @ 40 p.s.i.

Power: 13 – 13 watts

W & H TOPLIGHT

Noise: 62 dB (free running)

Power: 13 watts

SINORA

Noise: 60 – 64 dB

Speed: 150 000 – 250 000 r.p.m.

Power: 17 watts

NSK

Noise: 65 – 73 dB

Speed: 400 000 r.p.m.

Power: 14 watts

NSK TI-MAX A600L

Noise: 58 – 65 dB

Speed: 400 000 r.p.m.

Power: 14 watts

No speed was given for Synea and Toplight, but all new W & H handpieces are fitted with a “specially developed integral ball bearing system”.

4.2.3 **Summary Of Statistics** (as per the questionnaire)

(See attached appendix for complete statistics of the results of the questionnaire)

1601 questionnaires were mailed to practicing dentists in the Western Cape and central Gauteng areas. Replies were received from 518 dentists.

The response to the questionnaire was approximately 35% which according to Dr T. vW Kotze (2001) is statistically viable.

- The average age of the responding relies was 46 years old with a mean standard deviation of 13 years; with the youngest being 24 and the oldest 90. Four respondents were over the age of 80.

- The older practitioners had been using old style ball bearing type airotors after the introduction of airotors in South Africa from 1958. Only a small percentage never used the newer turbines or ultrasonics.

- The majority of dentists worked between 4½ – 6 days a week.

- The general dentists in the reduced sample of 460 have practised an average of 18½ years.

- There was not a large statistical difference between practising males and females (although the male to female ratio was 4½:1).

- There was not a statistical difference in the hours using airotors and turbines per day (approximately 8 hours daily).

- Female dentist displayed more variability in the number of days worked per week compared to males.

- Twenty-seven of the 460 dentists in the sample did not supply an estimate of the number of hours drilled per week. The coefficient of variation for this measurement was >50% which indicates excessive variability.

- There appears to be a difference in statistics for hearing loss and age, and hearing loss and years in practice. In the former, the increase in hearing was strictly monotone and the increase of hearing loss with respect to the interval midpoints might give an answer to whether the occupation of the respondents accelerates hearing loss. In the latter, the dentists using the turbine suffered a high proportion of hearing loss. This hearing loss was not monotonal in that the percentage of hearing loss in dentists in practice on an average of <30 years was 62½% and the percentage hearing loss in 35+ years of practice was 52%.

- According to the statistics, a small percentage used the older Borden and Sandri ball bearing handpieces. All these respondents have NIHL.

- Approximately 13.3% using air turbines and airotors had severe tinnitus with hearing loss in the higher frequencies.

- The moderate tinnitus and hearing sufferers accounted for about 26% of dental tinnitus sufferers.

- For all of the 358 general dentists using airotors and turbine handpieces about 26% reported that their hearing problems developed over an extended period. Only 4% said their problems started suddenly.

- The majority of those with tinnitus had hearing loss that was bilateral.

- Most tinnitus sufferers had a constant type of tinnitus, although about 41% were intermittent.

- Approximately 18% with tinnitus had sleep disturbances.

- Only a third of those with tinnitus had sought medical help, of which half had had an audiogram.

- 12.7% of hearing loss/tinnitus sufferers had a hearing aid of which 76% helped. (At the time of the questionnaire, there was no differentiation between the older analogue and the newer digital aids.)

5. CHAPTER FIVE

DISCUSSION

Of the five hundred and eighteen (518) replies obtained, 516 replies were from practitioners in private practice. The author and statistician who assisted with analysing the results are convinced that a large percentage of dentists who did not reply were academics at the Universities of the Witwatersrand, Stellenbosch and Western Cape. The reason for this assumption is that only two replies to the questionnaire were from academics (from University of Stellenbosch).

Since the advent of the air-driven handpiece, there have been studies that indicate that hearing loss may result from prolonged exposure to the high frequency pitch and noise level (dB) of this type of handpiece (Park 1978).

The author contacted the Medical Association of South Africa, the Audiological Association of South Africa, the Audiological Institute of South Africa and the Schools of Audiology at the Universities of Witwatersrand, Pretoria, Stellenbosch and Cape Town, and no statistics were available for non-dentists. Corresponding statistics for the general population of NIHL sufferers were found in the American literature.

According to a study of the literature it would appear that the prevalence of tinnitus due to the exposure to use of the air driven handpieces, is higher than that reported in the general adult population in the United States (Gullikson 1978).

The purpose of this thesis was to try and establish a possible correlation between incumbent noise in a dental environment and noise induced hearing loss.

The author has illustrated that a large percentage of dentists who provided information for the survey carried out for this thesis suffer ear pathology in the form of tinnitus, hearing loss (especially in the higher frequencies) and hyperacusis, or a combination thereof. In addition the percentage of dentists who suffer from the above mentioned ear pathologies is substantially higher than in the general public.

As mentioned previously no other equipment in the dental surgery creates a sound that is harmful. However it has been proved that the high-speed drill causes damage to the hearing apparatus. Thus one can postulate that there is a direct connection between noise levels and frequencies of the high-speed drill and the prevalence of tinnitus and hearing loss in dentists.

During the research, it was ascertained that the noise intensity of the handpiece is influenced by age and condition. According to the literature and discussions with manufacturers, as a handpiece gets older and its condition deteriorates, the noise level will increase by several decibels (Park 1978; Smith & Coles 1966; Taylor Pearson Mair 1965). Paul Park did a spot check of 11 manufacturers of similar ball-bearing, air turbines in his clinic and found all but one was below 80dB. One additional handpiece was operating at 92dB.

Park (1978) discovered that in all cases the intensity of noise was greater in the right ear than left ear. The average differential was approximately 5 dB, and it would appear that this is due to the position of the exhaust in the handpiece, which is closer to the right ear in right hand dentists.

Measurements taken in the author's own surgery, as well as in the other 31 dental surgeries, showed that the noise perceived by the chairside assistant, on the left of the dentist and patient, was significantly lower, i.e. greater than 8 – 10 dB lower. These levels were measured with spectrum analysers and SPL metres.

Naturally all disease processes involve both susceptibility and resistance to traumatic agents and/or pathogens. Hence all individual react differently to similar stimuli, and in the same individual the same stimulus may act differently e.g. the right ear in right handed dentists will usually have a greater degree of NIHL as opposed to the left ear, and vice versa.

NIHL is influenced by the characteristics of the noise i.e. intensity, frequency and spectrum of sound; duration of exposure; and the patient's disposition to develop NIHL from the effects of noise exposure. It is an oxymoron that persons suffering from NIHL will be hypersensitive to sound whilst suffering hearing loss. A typical NIHL audiogram will show high frequency hearing loss and a dip at 4000Hz.

The normal hearing threshold is usually 50 - 60dB at 3000 - 6000Hz (Vernon 1985). The author's threshold was measured at 50dB and the Tinnitus tones at 56dB, therefore the tinnitus is only 6dB over the threshold. According to Nagler, the dB range in the majority of tinnitus sufferers is only in the 5-8dB range. This very low dB level is sufficient to make sufferer's lives difficult.

According to Nagler, using Jastreboff's neurophysiological model of Tinnitus (see Fig. 6 p.73), the Tinnitus signal is recognised by the limbic system as an unwanted, threatening intruder. The limbic system grabs on to the signal and will not let go. This phenomenon is not a question of strength or "mind over matter" – rather it is totally beyond conscious control.

In the case of a possible hazard from noise (unwanted sound), one should not find comfort or panic from the ambivalence of the studies done over the years. The idea instead is to be alert that a potential hazard exists and the potential is increased in some individuals than in others.

A substantial number of Tinnitus Clinic patients in Portland, Oregon, report that their Tinnitus seems "louder' when they are experiencing fatigue or stress. It is not clear whether this reflects actual changes in the Tinnitus sensations or whether they represent reduced tolerance on the part of the individuals involved (Meikle and Griest, 1991).

At dental school, students (and staff) use protective apparatus such as eyeglasses, masks and gloves. As far as the author is aware, no students are ever taught about protection of the auditory organs, to use earmuffs or variphones and to ensure that the handpieces are new or in very good condition, to thus minimise noises in the dental environment.

6. CHAPTER SIX

CONCLUSION

The author has illustrated that a large percentage of dentists in the survey suffer from ear pathology in the form of Tinnitus, hearing loss (especially in the higher frequencies), and hyperacusis, or a combination thereof. Due to the findings of the research this could possibly be due to the "high speed drill".

In findings from the literature review, previous papers published 10 – 25 years ago, with a much smaller overall dental population, proved to be inconclusive (Forman-Franco et al. 1978; Park 1978; Coles & Hoare 1985; Smith and Coles 1985).

The statistical evidence of the questionnaires and results of tests in the working environment shows conclusively that noise exposure, in the form of "high speed drills", plays a significant causal role in the manifestation of NIHL and as such, dentists using airotor or air turbine type handpiece drills with a dB level in excess of 75-80dB are at risk.

Although tinnitus has a high prevalence in the general population, NIHL is not as prevalent, except in persons exposed to a noisy environment, as is evident amongst dentists.

Although the evidence as found by the author's survey (supported by the statistical analysis) does seem to be conclusive, it is important to note the following shortcomings:

- In order to show a definite relationship, audiological testing on all new dental students should be performed in order to exclude any possible pre-existing hearing loss.

- Other possible forms of exposure to noise needs to be excluded i.e. hobbies, music such as concerts, a Walkman™, raves and clubbing.
- Regular audiological testing needs to be done on all dentists using power drills.

While an association between Tinnitus and NIHL has been established, the impact the symptoms have on an individual's life varies enormously.

Permanent NIHL and the loss of that portion of one's life that depends on hearing, cannot be recovered, but it can be prevented (Park 1978).

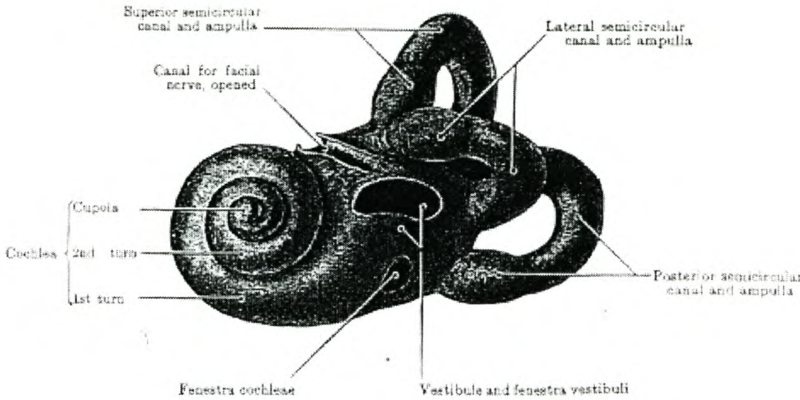
Although those individuals who already suffer form NIHL will not benefit appreciably due to the irreversible damage to the cochlear hairs, the author would undoubtedly suggest that all dentists in practice use the newer ball-bearing type handpieces running at 58-65dB.

Dentists should also have regular audiological tests to monitor their hearing status. In addition dentists should use ear protection against the noise levels, such as shottist's earmuffs or custom made ear protection e.g. variphones, that attenuate the sounds of the drills.

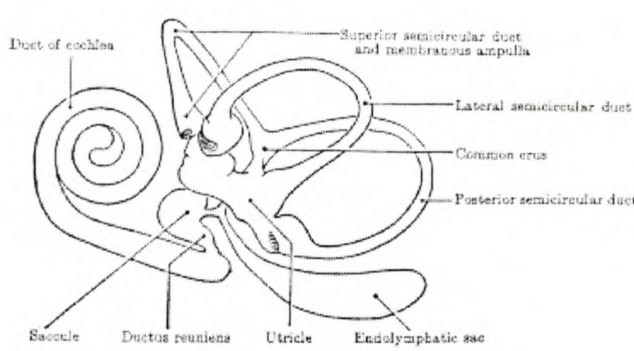
It is the author's opinion, that despite the very convincing evidence pointing to a direct causal relationship between high-speed dental drills and NIHL, further detailed investigations should be carried out in order to confirm the possibility that such a relationship does exist.

Illustration 1

The Bony labyrinth, lateral view, left side
The membranous labyrinth, lateral view, left side



The Bony Labyrinth, lateral view, left side.



The Membranous Labyrinth, lateral view, left side.

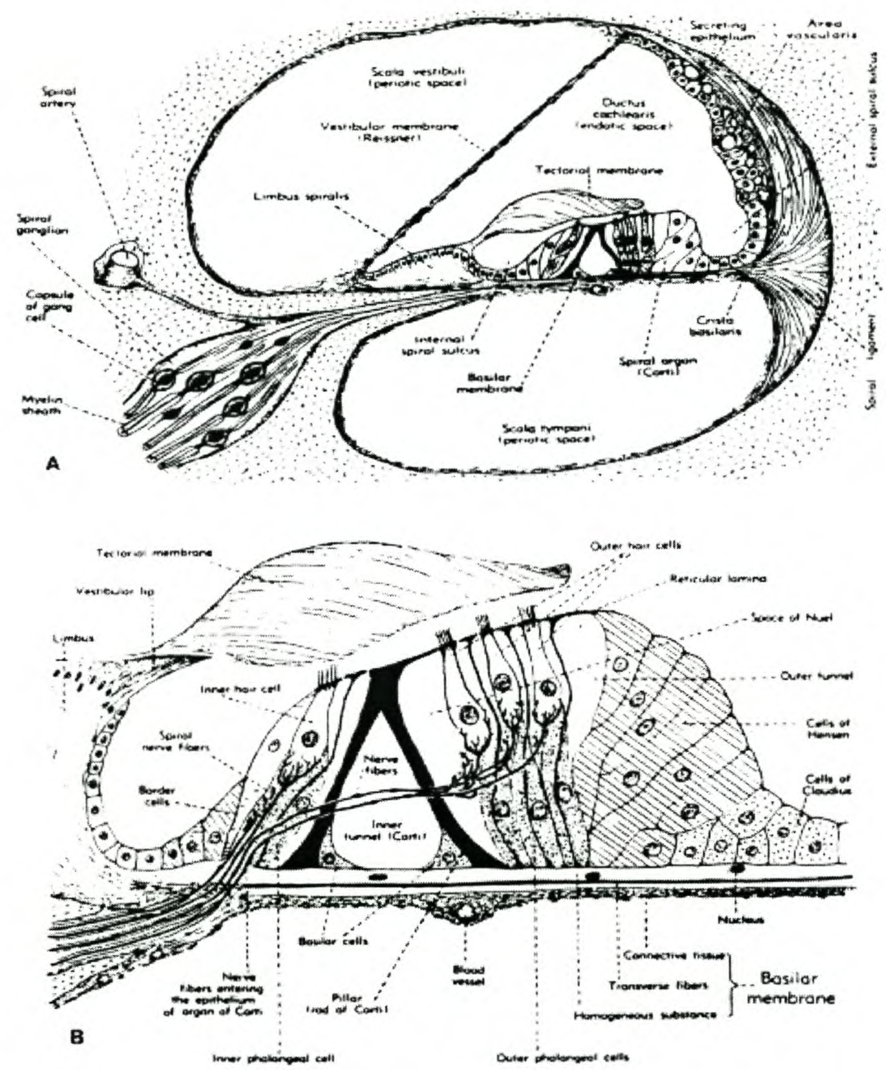
From a reconstruction made by Dr. Milne Dickie and Dr. J. S. Fraser.

(With Permission)

Illustration 2

A CROSS-SECTION OF ORGAN OF CORTI

A: low magnification B: high magnification

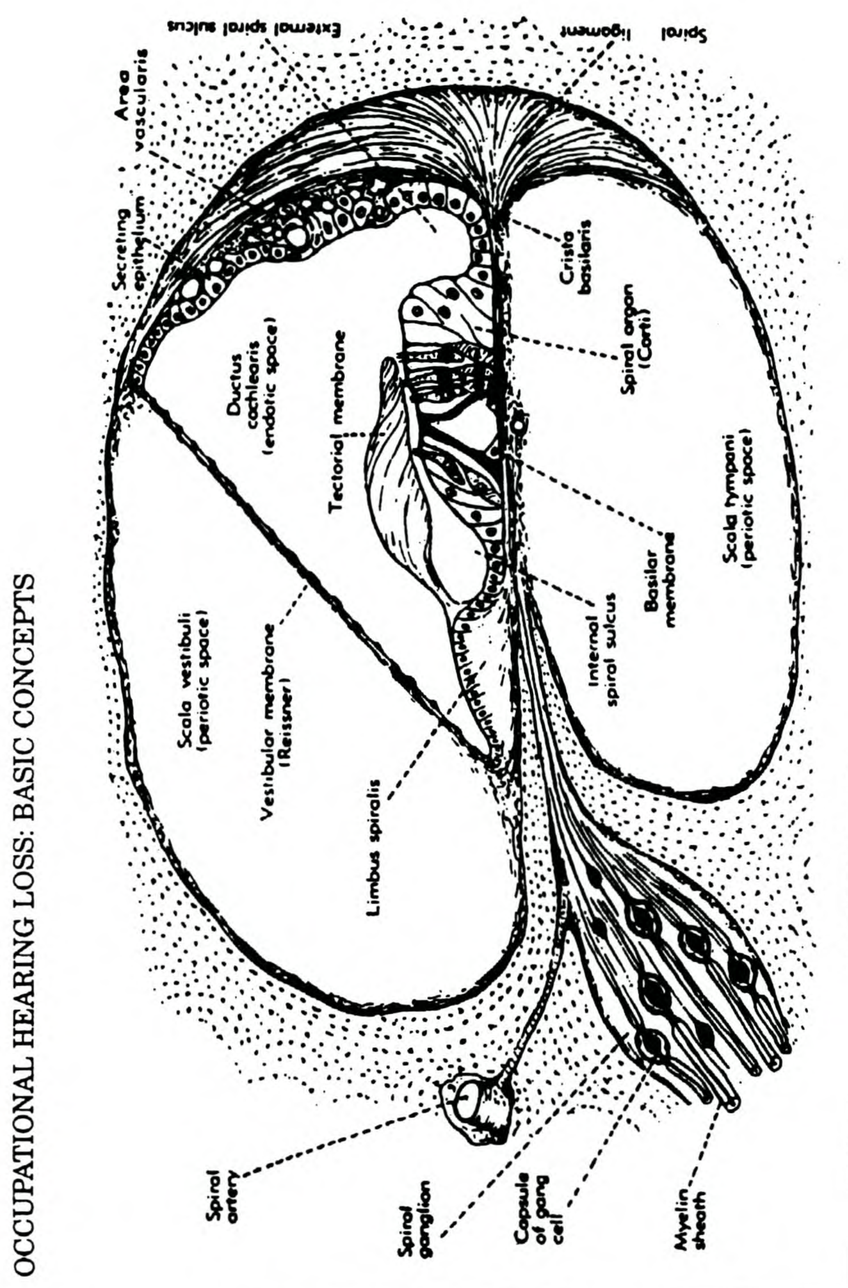


A cross-section of organ of Corti. **A.** low magnification. **B.** higher magnification. (From Sataloff RT, Sataloff J. *Occupational Hearing Loss*, 2nd ed. New York: Marcel Dekker; 1993; reprinted with permission.)

(From Sataloff RT, Sataloff J. Occupational Hearing Loss, 2[nd] ed. New York: Marcell Dekker; 1993) (With permission)

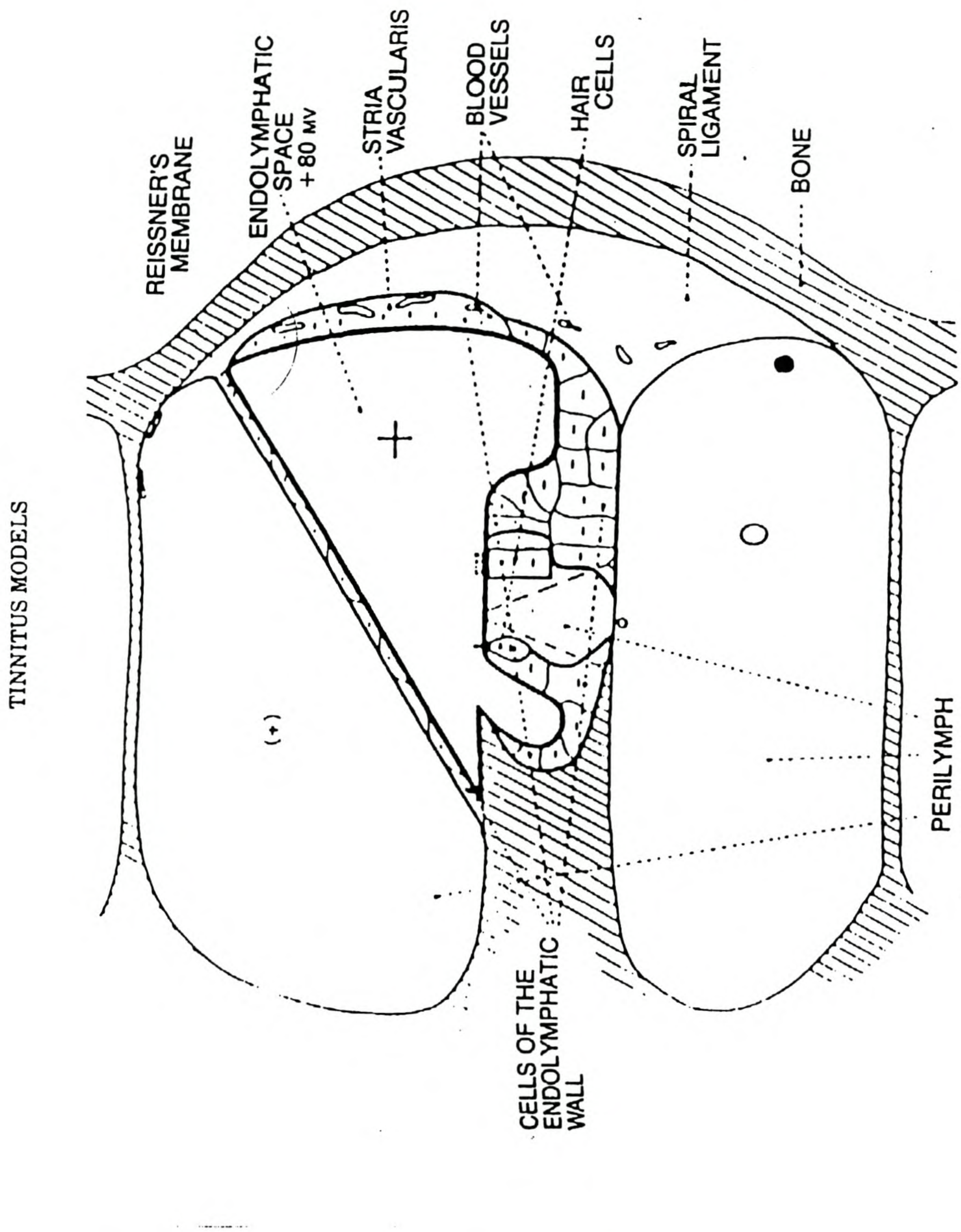
Illustration 3

OCCUPATIONAL HEARING LOSS: BASIC CONCEPTS



(From Sataloff RT, Sataloff J. Occupational Hearing Loss, 2nd ed. New York: Marcell Dekker; 1993) (With permission)

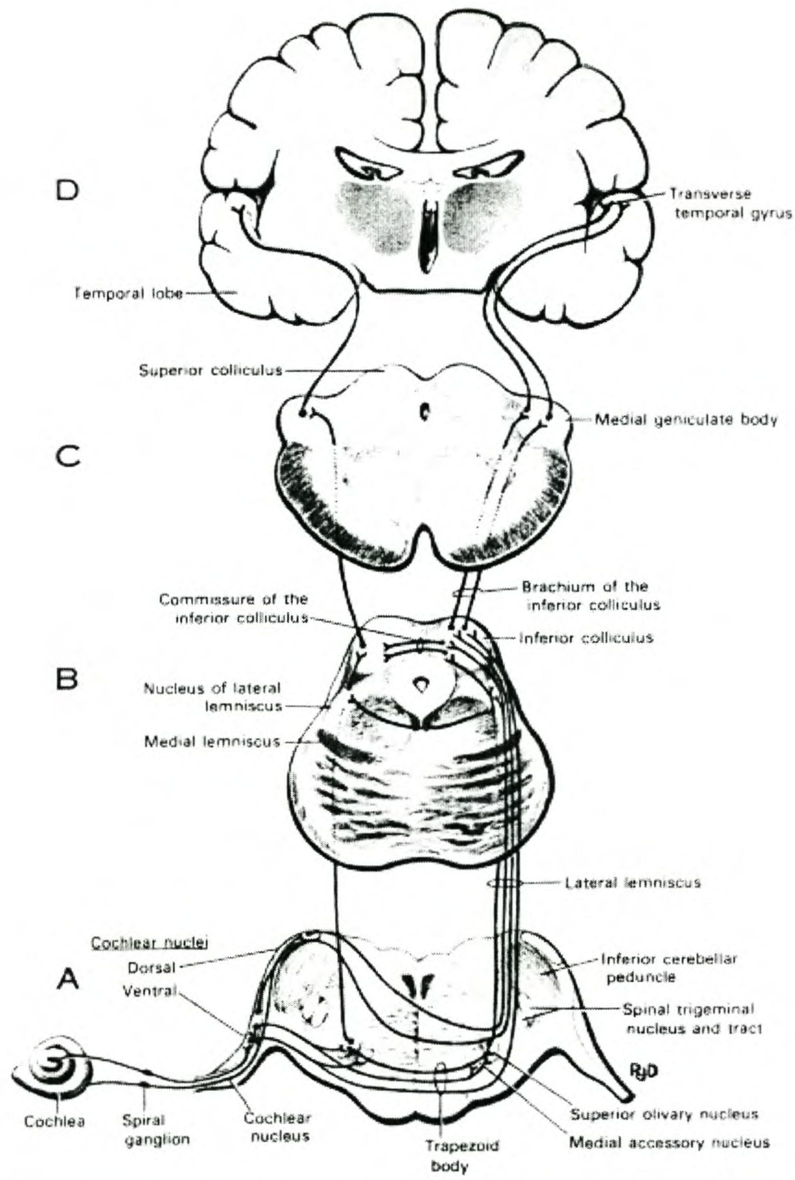
Illustration 4
TINNITUS MODELS



(From Sataloff RT, Sataloff J. Occupational Hearing Loss, 2nd ed. New York: Marcell Dekker; 1993) (With permission)

Illustration 5
AUDITORY BRAIN STEM RESPONSE AND TINNITUS

AUDITORY BRAIN STEM RESPONSE AND TINNITUS



Schematic diagram of the auditory pathways. *A.* Medulla. *B.* Level of inferior colliculus. *C.* Level of superior colliculus. *D.* Transverse section through the cerebral hemisphere. From Carpenter, M.: Core Text of Neuroanatomy. Baltimore, MD, Williams & Wilkins 1985, p. 140.

(From Carpenter, M: Core Text of Neuroanatomy. Baltimore, MD, Williams & Wilkins 1985 p.140) (With permission)

Figure 1

AUDIOGRAM OF NOISE INDUCED HEARING LOSS

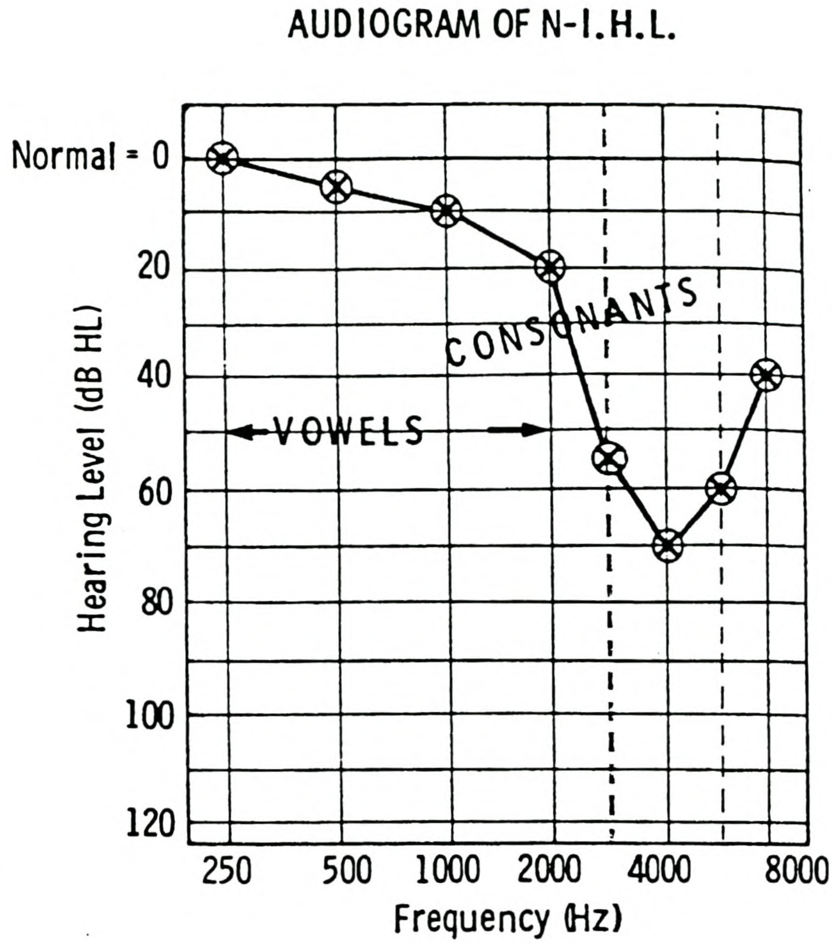
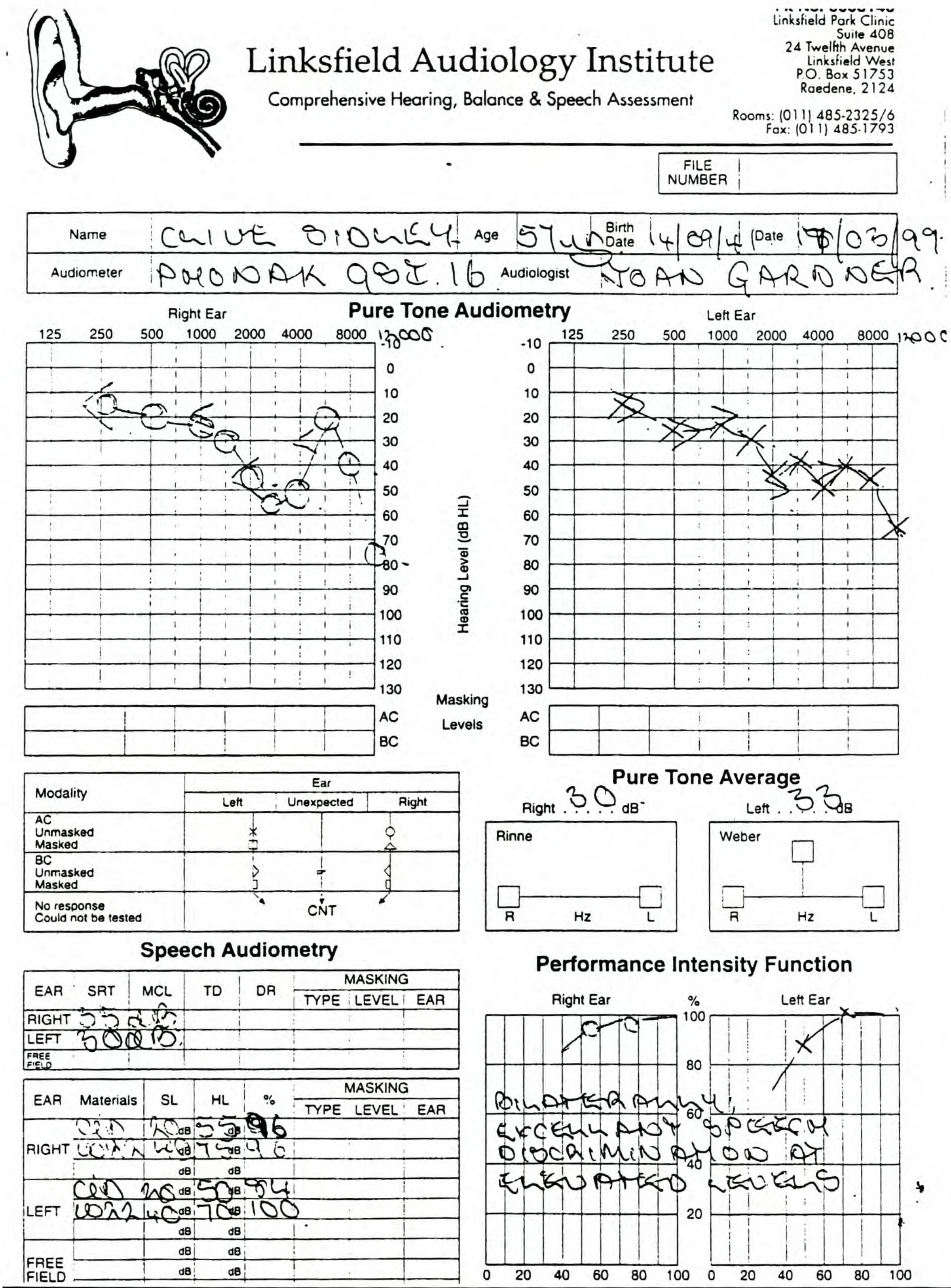
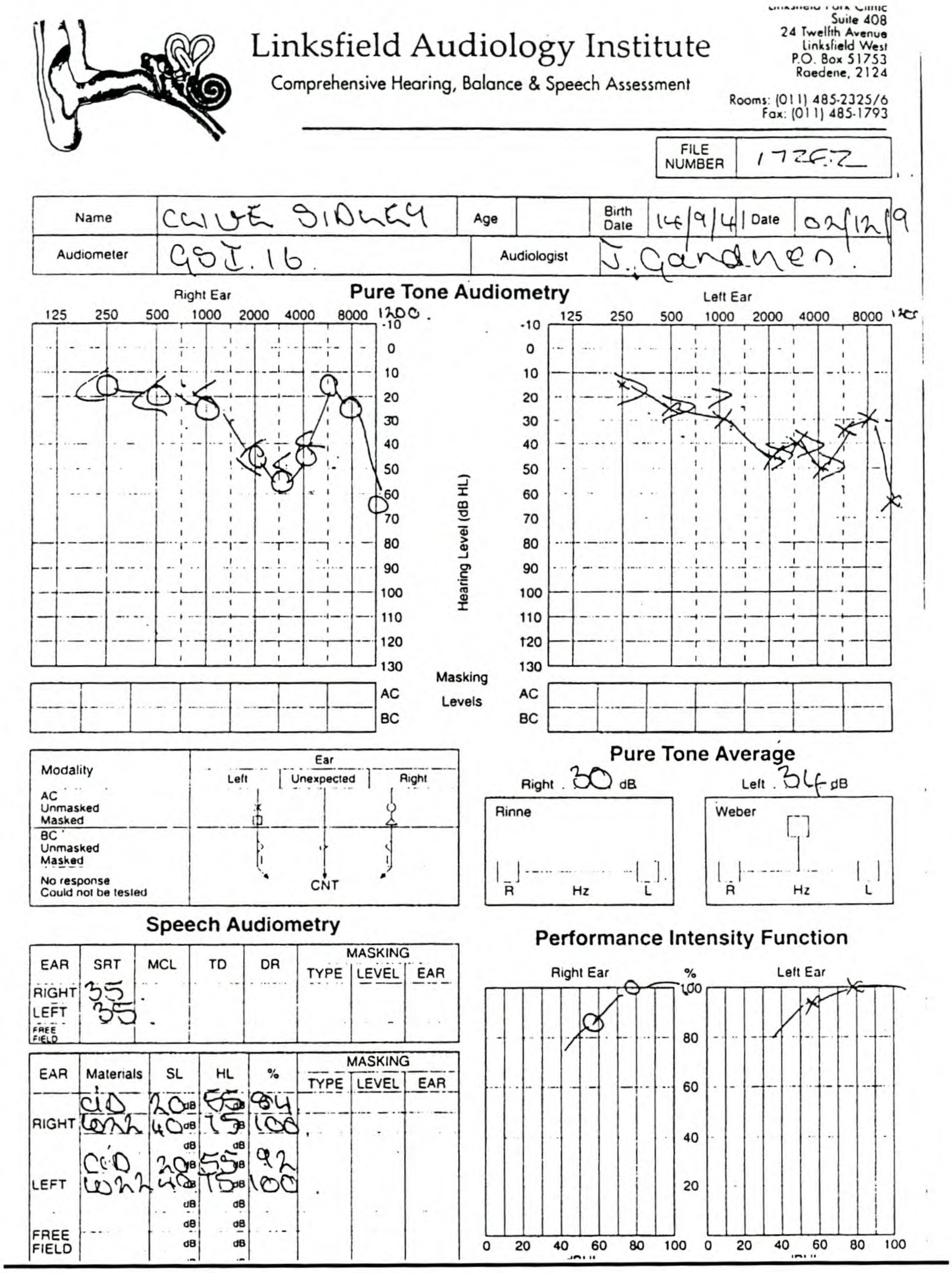


Fig. 1 Audiogram of a typical case of noise-induced hearing loss.

Figures 2-5

PERSONAL AUDIOGRAMS OF DR CLIVE SIDLEY:





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Linksfield West
P.O. Box 51753
Raedene, 2124

Rooms: (011) 485-2325/6
Fax: (011) 485-1793

FILE NUMBER: 17757

Name	CLIVE SIDLEY	Age		Birth Date	14/9/41	Date	02/12/9
Audiometer	GSI.16		Audiologist	J. Gardner			

Pure Tone Audiometry

Right Ear / Left Ear

125 250 500 1000 2000 4000 8000 12000

Hearing Level (dB HL): -10 0 10 20 30 40 50 60 70 80 90 100 110 120 130

Masking Levels: AC BC

Modality	Ear: Left	Unexpected	Right
AC Unmasked / Masked			
BC Unmasked / Masked			
No response / Could not be tested		CNT	

Pure Tone Average

Right 30 dB   Left 34 dB

Rinne: R Hz L

Weber: R Hz L

Speech Audiometry

EAR	SRT	MCL	TD	DR	MASKING TYPE	LEVEL	EAR
RIGHT	35						
LEFT	35						
FREE FIELD							

EAR	Materials	SL	HL	%	MASKING TYPE	LEVEL	EAR
RIGHT	CID	20 dB	55 dB	84			
RIGHT	W22	40 dB	75 dB	100			
LEFT	CID	20 dB	55 dB	92			
LEFT	W22	40 dB	75 dB	100			
FREE FIELD		dB	dB				

Performance Intensity Function

Right Ear / Left Ear

% 100 80 60 40 20

0 20 40 60 80 100 dB HL

DR. H. HAMERSMA

M.B. Ch.B. (Pret.) M.D. Amsterdam

Oor-, Neus- en Keelspesialis – Ear, Nose and Throat Specialist

Botesstraat 2
Florida Park
Transvaal
5973, Weltevredenpark, 1715

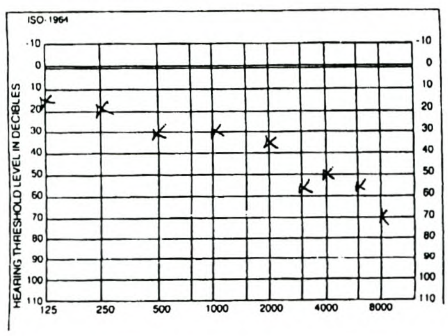
2 Botes Street
Florida Park
Transvaal
(011) 472-3517
F: 472-3519

D Fidley

28 JAN [illegible]

AUDIOGRAM

(L)

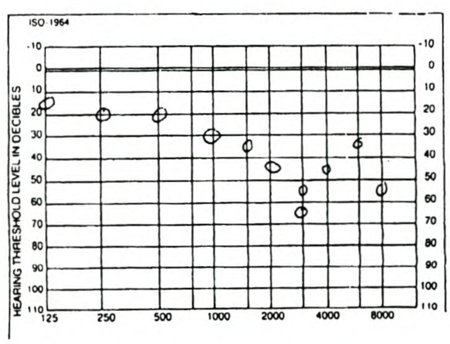


AUDIOGRAM KEY

	RIGHT	LEFT
Unmasked air conduction	O	X
Masked air conduction	△	□
Unmasked bone conduction	<	>
Masked bone conduction	[	]
No Response	↓	↓

Bone conduction heard in the opposite ear = ∩ ∧

(R)



A.M.A. % HEARING LOSS		
L.____	R.____	COMB.____

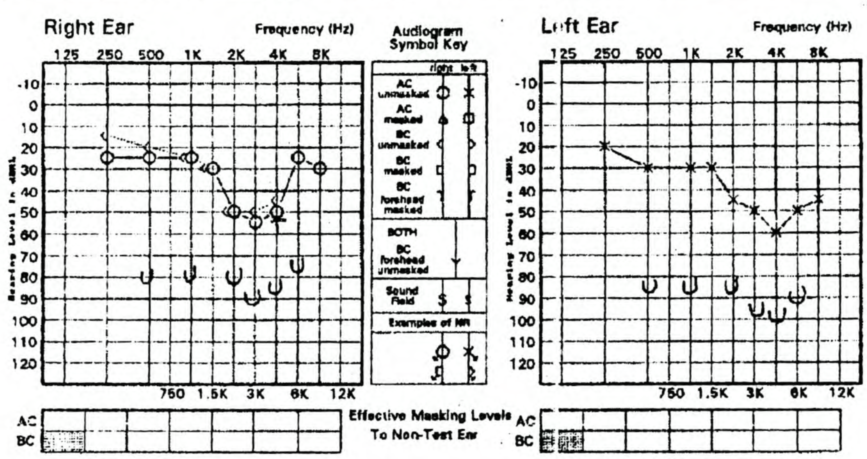
This audiogram is plotted on the basis of:
☐ 1964 ISO reference thresholds

SOUTHEASTERN COMPREHENSIVE TINNITUS CLINIC

Name : Clive Sidley ID # :

Age : 57 Sex : F M Date : 4/19/99 Time :

GSI 61 Audiometer S/N : Tester : EJJ Reliability : Good



	PTA	MCL	UCL	SRT	Speech Discrimination
				Speech Audiometry	
RIGHT	33	70	85	30dB HL	100%
LEFT	35	65	85	30dB HL	100%
				CD ☒ Tape ☐	MLV ☐

Comments :

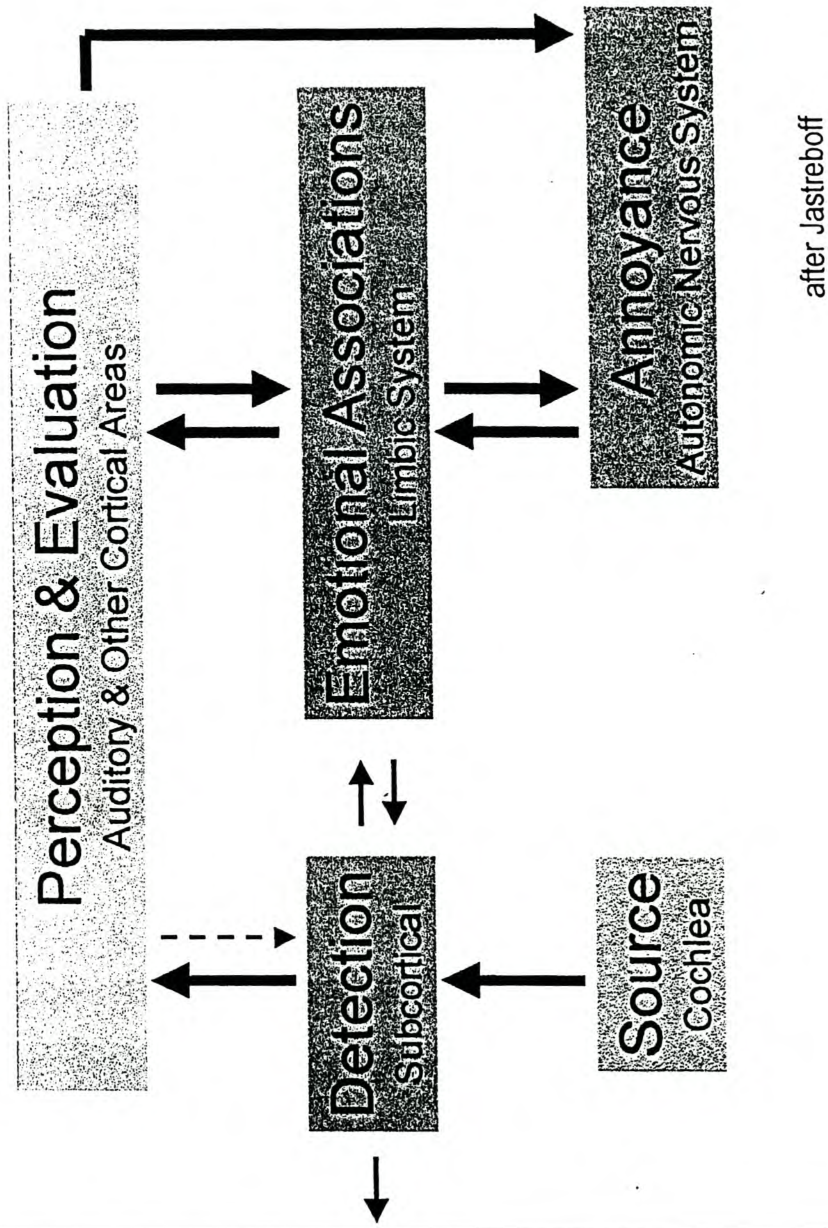
T = Tinnitus

U = Loudness Discomfort Level

Figure 6

JASTREBOFF'S NEUROPHYSIOLOGICAL MODEL OF TINNITUS

Jastreboff (1995) [a]



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APPENDIX

REPORT ON THE ANALYSIS OF THE PREVALENCE OF TINNITUS AMONGST DENTAL PRACTITIONERS FOR THE MASTERS DEGREE OF DR CLIVE SIDLEY.

INTRODUCTION
Demography of Respondents

Approximately 1530 questionnaires were mailed to practising dentists by means of the mailing list of registered dentists and specialists in that field.
The total number of participants within the study was 517 dentists and other dental specialists (hereafter referred to as dentists according to the majority of respondents). This sample contained approximately 52 specialists. The average age of this group was 45.6 years with a standard deviation of 12.6 years; the minimum age being 24 and the maximum 90 years. The maximum of 90 years was clearly in the extreme tail of the age distribution; four participants (with ages 84, 85, 89 and 90) exceeded the age of 80.

Respondents were asked which handpieces they used for Airotor*, Air Turbine* or Ultrasonic* applications (*according to questionnaire). From the 517 respondents 400 used the Airotor, 469 used the Air Turbine and 348 used the Ultrasonics handpieces in their practice, up to the present. Of the 517 dentists 288 (nearly 56%) have used all three handpieces in their career. All the Airotor users are contained in the upper half of the table below. The 400 Airotor users are known in statistical terminology as the *marginal count* and the compliment of 117 respondents who did not use the Airotor handpiece is known as the *complementary marginal count.* The 400 Airotor users can further be divided according to their use of the Air Turbine and Ultrasonics handpieces.

Table 1

Three-dimensional Frequency table of the Career Usage of Three Hand Pieces up to the present

Airotor used?	Yes		
	Air Turbine		
Ultrasonics	Yes	(blank)	All
Yes	288	9	297
(blank)	74	29	103
Total Count	362	38	400
Airotor used?	No		
	Air Turbine		
Ultrasonics	Yes	(blank)	All
Yes	48	3	51
(blank)	59	7	66
Total Count	107	10	117

Of the 400 Airotor users only 29 did not use the Ultrasonics or Air Turbine handpieces. Of the 117 respondents who never used the Airotor handpiece, 7 dentists (1.4% out of the complete (517) sample) used none of the three handpieces. (See shaded part of table above). The reader can train himself in finding each of the eight possible combinations of handpiece usage.

The usage of *ear protection whilst using drills* was extremely low, (only 12 respondents) and no significant difference could be detected between the users of the three types of handpieces. Such an investigation with extremely low *ear protection* usage is illogical due to the eight possible combinations of handpiece-availability (see Table 1) and patterns in time and duration.

Table 2

Number of Days worked per Week according to Gender of the Dentist

		Gender			
Days per week		**Male**	**Female**	**(blank)**	**All Groups**
0.5	# Filled in	1	0	0	1
	Column %	0.2%	0.0%	0.0%	0.2%
2	# Filled in		1	1	2
	Column %	0.0%	1.9%	4.2%	0.4%
2.5	# Filled in	0	1	0	1
	Column %	0.0%	1.9%	0.0%	0.2%
3	# Filled in	2	2	0	4
	Column %	0.5%	3.8%	0.0%	0.8%
3.5	# Filled in	1	0	0	1
	Column %	0.2%	0.0%	0.0%	0.2%
4	# Filled in	17	5	1	23
	Column %	3.9%	9.6%	4.2%	4.4%
4.5	# Filled in	40	3	1	44
	Column %	9.1%	5.8%	4.2%	8.5%
5	# Filled in	259	17	16	292
	Column %	58.7%	32.7%	66.7%	56.5%
5.5	# Filled in	52	7	3	62
	Column %	11.8%	13.5%	12.5%	12.0%
6	# Filled in	63	14	2	79
	Column %	14.3%	26.9%	8.3%	15.3%
6.5	# Filled in	1	0	0	1
	Column %	0.2%	0.0%	0.0%	0.2%
7	# Filled in	2	1	0	3
	Column %	0.5%	1.9%	0.0%	0.6%
(blank)	# Filled in	3	1	0	4
	Column %	0.7%	1.9%	0.0%	0.8%
Column Total		441	52	24	517
Column %		100.0%	100.0%	100.0%	100.0%

Only 31 respondents worked four days or less; 336 worked between four-and-a- half to five days per week; 141 worked, at the time of the survey, for five-and-a- half to six days per week and only 4 respondents worked more than six days per week. Due to the small number of dentists who worked four days or less per week, the information in the table above was summarised according to the shaded areas.

Table 3

Number of Days *(summarised to logical entities)* worked per Week According to Gender of the Dentists

		Gender			
Days per week		**Male**	**Female**	**(blank)**	All Groups
<4	# Filled in	21	9	2	31
	Column %	4.8%	17.3%	8.3%	6.00%
4.5 - 5	# Filled in	299	20	17	336
	Column %	67.8%	38.5%	70.8%	64.99%
5.5 - 6	# Filled in	115	21	5	141
	Column %	26.1%	40.4%	20.8%	27.27%
6.5 -	# Filled in	3	1	0	4
	Column %	0.7%	1.9%	0.0%	0.77%
(blank)	# Filled in	3	1	0	4
	Column %	0.7%	1.9%	0.0%	0.77%
Column Total		441	52	24	517
Column %		100.00%	100.00%	100.00%	100.00%

The respondents supplied the *number of days worked per week* in most cases; only four missing values (see rows). Twenty-four respondents did not supply their gender and the distribution of the number of working days per week would not be discussed for them.

From the original sample the specialists (52 in number) and four general dentists whose age was eighty years or more, were removed. Another dentist who practised for an extremely short period, was also removed to reach a reasonably homogeneous sample of 460 general dentists on which the analysis would be based. While it was postulated that the equipment such as the Airotor, Air Turbine and Ultrasonics might be responsible for Hearing Loss at an earlier stage than the effect of normal ageing, the usage of these tools would be investigated. However, the age of the subjects would also be taken into consideration for the selected group (460 general dentists).

Table X

Three-dimensional Frequency table of the Career Usage, up to the present, of Three Hand Pieces

Airotor used	Yes		
	Air Turbine used		
Ultrasonics used	yes	(blank)	Total
yes	266	7	273
(blank)	68	17	85
Grand Total	334	24	358
Airotor used	(blank)		
	Air Turbine used		
Ultrasonics used	yes	(blank)	Total
yes	45	1	46
(blank)	52	4	56
Grand Total	97	5	102

Of the 460 general dentists, 266 (57.8%) used all three handpieces. Only four (less than one percent) dentists used none of the mentioned handpieces. From this it could be observed that it was extremely unlikely to use none of the three mentioned handpieces and occurrence of this unlikely event was slightly higher in the complete sample (7 out of 517). Of the 460 general dentists; 358 (77.8%) used the Airotor; 431 (334 + 45) (93.7%) used the Air turbine and 319 (273 + 46) (69.3%) used the Ultrasonic handpiece. The next table provides information on the age distribution, and Hearing loss and Gender.

Table X

Hearing Loss and Gender used as classifiers for the Descriptive Statistics of Age

		Gender			
Hearing Loss	Data	Female	Male	(blank)	**All**
No	Number of Qs	33	214	9	**256**
	# Age filled in	33	213	9	**255**
	Average of Age	35.1	43.4	56.0	**42.7**
	StdDev of Age	6.29	10.68	15.02	**11.03**
	Minimum	25	25	33	**25**
	Maximum	50	79	79	**79**
Yes	Number of Qs	16	156	11	**183**
	# Age filled in	16	155	11	**182**
	Average of Age	36.5	48.8	52.4	**48.0**
	StdDev of Age	8.14	12.74	11.35	**12.82**
	Minimum	26	25	37	**25**
	Maximum	52	78	71	**78**
(blank)	Number of Qs	1	19	1	**21**
	# Age filled in	1	19	1	**21**
	Average of Age	45.0	47.8	74.0	**48.9**
	StdDev of Age	#DIV/0!	12.85	#DIV/0!	**13.49**
	Minimum	45	33	74	**33**
	Maximum	45	72	74	**74**
Number of Qs (combined)		**50**	**389**	**21**	460
# Age filled in (combined)		**50**	**387**	**21**	458
Average of Age (combined)		**35.7**	**45.8**	**55.0**	45.1
StdDev of Age (combined)		**6.96**	**11.93**	**13.31**	12.15
Minimum		**25**	**25**	**33**	25
Maximum		**52**	**79**	**79**	79

In the bottom right hand cell it could be observed that this table contains the information of 460 dentists of which 458 provided their age. The average age of these respondents (458) was 45.1 years (Std Dev 12.15). Of the 458 dentists who provided their age, the maximum age was 79 and the minimum age was 25. The table above contains nine cells specified by the classes of hearing loss and gender (three classes each). The bolded numbers on the edge (margin) of the table provide the descriptive statistics of Age with respect to only one of the two classifiers (Gender or Hearing loss). Something interesting of the above table was that twenty-one of the respondents did not provide their gender but twenty of them provided their age. The same twenty-one respondents also did not provide information on whether they had any Hearing loss or not.

From the above table the averages of those dentists not suffering any Hearing loss were 35.1 years for the females and 43.4 years for the males, whereas the corresponding averages for those who suffered Hearing loss were 36.5 years and 48.8 years. It could be observed that the difference between the two averages of the females was small (1.4 years) compared to a difference of 5.4 years for the males. No explanation could be offered for this discrepancy between the genders.

It could also be deduced that 183 (39.8%) of the respondents complained of Hearing loss. Thirty-two percent of the female dentists and 40.1% of the male dentists had some Hearing loss. This difference could possibly be ascribed to a gender difference and/or different working habits in using the handpieces.

The next table provides descriptive statistics of *Number of Years in Practice* but this was not specifically recorded with respect to the usage of the three handpieces.

Table X

Three-dimensional table of the Career Usage, up to the present, of Three Hand Pieces and the Descriptive Statistics of *Number of Years in Practice* (#Years_i_P) in the eight cells formed by the usage (or not) of the three handpieces

Airotor	Yes

		Air Turbine		
Ultrasonics	Data	Yes	(blank)	All
Yes	Number of Qs	266	7	273
	# Years_i_P filled in	264	7	271
	Average of Years_i_P	18.7	31.7	19.1
	StdDev of Years_i_P	11.84	11.06	11.98
	Minimum	1	17	1
	Maximum	52	46	52
(blank)	Number of Qs	68	17	85
	# Years_i_P filled in	68	17	85
	Average of Years_i_P	20.8	29.4	22.5
	StdDev of Years_i_P	11.40	10.97	11.78
	Minimum	1	8	1
	Maximum	50	43	50
Number of Qs in combined groups		334	24	358
# Years_i_P filled in (combined)		332	24	356
Average of Years_i_P (combined)		19.1	30.1	19.9
StdDev of Years_i_P (combined)		11.76	10.80	12.00
Minimum		1	8	1
Maximum		52	46	52

Airotor	(blank)

		Air Turbine		
Ultrasonics	Data	Yes	(blank)	All
Yes	Number of Qs	45	1	46
	# Years_i_P filled in	45	1	46
	Average of Years_i_P	17.6	34.0	18.0
	StdDev of Years_i_P	10.56		10.72
	Minimum	2	34	2
	Maximum	50	34	50
(blank)	Number of Qs	52	4	56
	# Years_i_P filled in	51	4	55
	Average of Years_i_P	18.5	25.0	19.0
	StdDev of Years_i_P	12.72	21.37	13.34
	Minimum	1	1	1
	Maximum	50	44	50
Number of Qs in combined groups		97	5	102
# Years_i_P filled in (combined)		96	5	101
Average of Years_i_P (combined)		18.1	26.8	18.5
StdDev of Years_i_P (combined)		11.70	18.94	12.17
Minimum		1	1	1
Maximum		50	44	50

The general dentists in the sample of 460 practised an average of 18.5 years and the 266 dentists who used all three handpieces practised on average for 18.7 years. This was because the 266 dentists formed the majority of the sample of 460. However, the averages in the individual cells differed considerably for example, 17 dentists who only used the Airotor were on average 29.4 years in practice and 7dentists who used the Airotor as well as the Air turbine was 31.7 years in practice.

The next table provides information on the distribution of *Hours per Day*, and Hearing loss and Gender. This was done in order to assess the relationship of Gender and Hearing loss on *Number of Hours in Practice per Day*.

Table X

Descriptive Statistics of *Number of Hours in Practice per Day* for the Classes of *Gender* and *Hearing Loss*

		Gender			
Hearing Loss	Data	Female	Male	(blank)	All
No	Number of Qs	33	214	9	256
	# Hours per day	33	213	9	255
	Average of hours per day	7.8	8.3	8.1	8.3
	StdDev of Hours per day	1.81	1.22	0.95	1.31
	Minimum	3	3	6	3
	Maximum	12	12	9	12
Yes	Number of Qs	16	156	11	183
	# Hours per day	16	156	11	183
	Average of hours per day	7.8	8.4	8.6	8.3
	StdDev of Hours per day	1.60	1.44	1.86	1.48
	Minimum	4	3	7	3
	Maximum	10	14	14	14
(blank)	Number of Qs	1	19	1	21
	# Hours per day	1	19	1	21
	Average of hours per day	8.0	8.1	6.0	8.0
	StdDev of Hours per day	—	0.85	—	0.92
	Minimum	8	7	6	6
	Maximum	8	10	6	10
Number of Qs (combined)		50	389	21	460
# Hours per day filled in (combined)		50	388	21	459
Average of hours per day (combined)		7.8	8.3	8.3	8.3
StdDev of hours per day (combined)		1.71	1.30	1.56	1.37
Total Min of hours per day		3	3	6	3
Total Max of hours per day		12	14	14	14

From this table it was learned that for this particular group of dentists, females (7.8 hours) worked on average approximately half an hour less than their male counterparts (8.3 hours). The minimum hours worked per day were three and the maximum number of hours were fourteen in the complete group and the maximum hours worked by the females were less, namely twelve. The females with any Hearing loss worked on average the same number of hours per day compared to the sixteen with no Hearing loss. The males with any Hearing loss worked on average slightly more hours per day (8.4 hours) compared to the 214 dentists with no Hearing loss (8.3 hours).

Table X

Hearing Loss and Gender used as classifiers for the Descriptive Statistics of *Number of Days per Week*

		Gender			
Hearing Loss	Data	Female	Male	(blank)	All
No	Number of Qs	33	214	9	256
	#Days per week	33	213	9	255
	Average of days per week	5.0	5.2	4.7	5.2
	StdDev of days per week	1.15	0.52	1.03	0.66
	Minimum	2	4	2	2
	Maximum	7	7	5.5	7
Yes	Number of Qs	16	156	11	183
	#Days per week	16	156	11	183
	Average of days per week	5.2	5.1	5.2	5.1
	StdDev of days per week	0.65	0.48	0.47	0.49
	Minimum	4	3	4.5	3
	Maximum	6	6.5	6	6.5
(blank)	Number of Qs	1	19	1	21
	#Days per week	1	19	1	21
	Average of days per week	5.0	5.2	5.0	5.2
	StdDev of days per week	—	0.45	—	0.44
	Minimum	5	4.5	5	4.5
	Maximum	5	6	5	6
Number of Qs (combined)		50	389	21	460
# Hours days per week filled in (combined)		50	388	21	459
Average of days per week (combined)		5.1	5.1	5.0	5.1
StdDev of days per week (combined)		0.99	0.50	0.77	0.59
Total Min of days per week		2	3	2	2
Total Max of days per week		7	7	6	7

From the table above it is clear that these dentists worked approximately 5.1 days per week. This differed only slightly in the various cells formed by Hearing loss and Gender. Something that could be observed from the female dentists was that they displayed more variability in the number of days worked per week compared to the males.

Table X

Hearing Loss and Gender used as classifiers for the Descriptive Statistics of *Number of Hours Drilled per Week*

		Gender			
Hearing Loss	Data	Female	Male	(blank)	All
No	Number of Qs	33	214	9	256
	#Hours drill	32	203	9	244
	Average of hours drill	23.5	21.3	15.2	21.3
	StdDev of hours drill	12.42	12.65	8.23	12.53
	Minimum	2	0.5	5	0.5
	Maximum	50	60	30	60
Yes	Number of Qs	16	156	11	183
	#Hours drill	16	146	9	171
	Average of hours drill	22.2	20.5	25.6	21.0
	StdDev of hours drill	14.04	12.10	12.72	12.30
	Minimum	4	2	6	2
	Maximum	40	52	50	52
(blank)	Number of Qs	1	19	1	21
	#Hours drill	1	16	1	18
	Average of hours drill	25.0	19.6	5.0	19.1
	StdDev of hours drill	—	9.66	—	9.81
	Minimum	25	4	5	4
	Maximum	25	40	5	40
Number of Qs (combined)		50	389	21	460
# Hours drill (combined)		49	365	19	433
Average of hours drill (combined)		23.1	20.9	19.6	21.1
StdDev of hours drill (combined)		12.72	12.30	11.91	12.32
Total Min of hours drill		2	0.5	5	0.5
Total Max of hours drill		50	60	50	60

This measurement is highly suspicious to the Data Analyst because he questions the ability of the subjects in the sample to estimate the average *number of hours drilled per week*. Twenty-seven of the 460 dentists in the sample did not supply an estimate of *number of hours drilled per week.* The coefficient of variation for this measurement was 58.4% which indicated excessive variability. The averages in the cells did not vary extremely and no significant differences existed between the means of the main factors in the table above. Of major importance was that there was no difference between the subjects with Hearing loss (21.0 hours) and those with no Hearing loss (21.3 hours). This was likely due to the poor estimation of the *number of hours drilled per week* or that the number of years in practice was not taken into account.

To quantify the *age of the dentist* and *years in practice*, two major risk factors, it was decided to divide these two variables into reasonable intervals for each of the 460 dentists.

The table below shows the boundaries of the intervals and the relationship between these two sets of intervals.

Table XX

Frequency table of the *Age of the dentist* and *Years in practice*

	Age Interval in Years					
Interval for Years in Practice	<30	30_39	40_49	50_	(blank)	All
0_14	159	15	3	—	—	177
15_24	8	122	17	4	—	151
25_34	—	7	54	2	—	63
35_	—	—	5	59	2	66
(blank)	1	1	1	—	—	3
Total	168	145	80	65	2	460

An extremely low number of respondents omitted their *Age* and *Years in practice*. The choice of the boundaries of the intervals was done in such a manner to fit in with the assumption that the Hearing loss occurred after a long period of age related and/or occupation induced deafness. The question was whether the occupation of being a dentist and/or using high frequency equipment accelerated the loss of hearing.

In the next set of tables the presence of Hearing loss or the absence thereof were related with the *Intervals of Years in Practice* and the *Age Intervals*. The category of "blanks" in the *Intervals of Years in Practice* and the *Age Intervals* would be omitted in any of the tables where either of these interval sets occur. The main reason for omitting the "blank" categories was that it did not add to the available information contained in all these tables. The "blank" categories for Hearing loss were combined (or collapsed) with the "No" column of Hearing loss.

Table XXX

Frequency table of *Hearing Loss* and *Intervals for Years in Practice* for respondents who ever used the Airotor handpiece

	Hearing Loss			
Interval for Years in Practice	No	Yes	% Hearing Loss	All
0_14	89	43	32.6%	132
15_24	76	46	37.7%	122
25_34	20	29	59.2%	49
35_	26	27	50.9%	53
Total	211	145	40.8%	356

A very high proportion of the respondents who ever used the Airotor handpiece suffered Hearing Loss (40.8%). This high proportion of respondents suffering from Hearing Loss was likely due to bias in the sampling in that dentists with some deafness were more likely to respond to this survey. An increase in the percentage Hearing Loss was observed in the table above but this increase was not monotone in that the percentage Hearing Loss in the interval '25_34 years' was 59.2% and that the percentage Hearing Loss in the interval '>34 years' was 50.9%.

Table XXX

Frequency table of *Hearing Loss* and *Age Interval* for respondents who ever used the Airotor handpiece

	Hearing Loss			
Age Interval in Years	No	Yes	%Hearing Loss	All
<30	82	42	33.9%	124
30_39	74	43	36.8%	117
40_49	31	33	51.6%	64
50_	24	27	52.9%	51
Total	211	145	40.8%	356

An increase in the percentage Hearing Loss was observed in the table above and this increase was strictly monotone. To study the slope of the increase in the proportion of Hearing Loss with respect to the interval midpoints might give an answer to the question whether the occupation of the respondents accelerates the presence of Hearing Loss.

Table XXX

Frequency table of *Hearing Loss* and *Interval for Years in Practice* for respondents who ever used the Air Turbine handpiece

	Hearing Loss			
Interval for Years in Practice	No	Yes	Hearing_Loss	All
0_14	120	52	30.2%	172
15_24	89	57	39.0%	146
25_34	21	35	62.5%	56
35_	26	28	51.9%	54
Total	256	172	40.1%	428

As before a very high proportion of the respondents who ever used the Air Turbine handpiece suffered Hearing Loss (40.1%). An increase in the percentage Hearing Loss was observed in the table above but this increase was not monotone in that the percentage Hearing Loss in the interval '25_34 years' was 62.5% and that the percentage Hearing Loss in the interval '35_ years' was 51.9%.

Table XXX

Frequency table of *Hearing Loss* and *Age Interval* for respondents who ever used the Air Turbine handpiece

	Hearing Loss			
Age Interval in Years	No	Yes	%Hearing Loss	All
<30	112	51	31.3%	163
30_39	90	51	36.2%	141
40_49	31	41	56.9%	72
50_	24	29	54.7%	53
Total	257	172	40.1%	429

An increase in the percentage Hearing Loss was observed in the table above but this increase was nearly strictly monotone in that the percentage Hearing Loss in the interval '40_49 years' was 56.9% and that the percentage Hearing Loss in the interval '50_ years' was 54.7%.

Table XXX

Frequency table of *Hearing Loss* and *Interval for Years in Practice* for respondents who ever used the Ultrasonics handpiece

	Hearing Loss			
Interval for Years in Practice	No	Yes	Hearing Loss	All
0_14	87	40	31.5%	127
15_24	64	43	40.2%	107
25_34	15	31	67.4%	46
35_	15	22	59.5%	37
Total	181	136	42.9%	317

As before a very high proportion of the respondents who ever used the Ultrasonics handpiece suffered Hearing Loss (42.9%). An increase in the percentage Hearing Loss was observed in the table above but this increase was not monotone in that the percentage Hearing Loss in the interval '25_34 years' was 67.4% and that the percentage Hearing Loss in the interval '35_ years' was 59.5%.

Table XXX

Frequency table of *Hearing Loss* and *Age Interval* for respondents who ever used the Ultrasonics handpiece

	Hearing Loss			
Age Interval in Years	No	Yes	% Hearing Loss	All
<30	82	41	33.3%	123
30_39	62	38	38.0%	100
40_49	22	35	61.4%	57
50_	16	22	57.9%	38
Total	182	136	42.9%	318

An increase in the percentage Hearing Loss was observed in the table above but this increase was nearly strictly monotone in that the percentage Hearing Loss in the interval '40_49 years' was 61.4% and that the percentage Hearing Loss in the interval '50_ years' was 57.9%.

In the tables to follow, the replies to the question on the severity of the Hearing Loss: *Is it mild, severe, moderate?* stated by the respondents were summarised together with the *Interval for Years in Practice* and *Age Interval in Years.* The ordinal classes "Moderate" and "Severe" were also grouped together in these tables.

Table XXX

Frequency Table of *Severity Grading* and *Interval for Years in Practice* for those dentists who ever used the Airotor handpiece

	Severity Grading							
Interval for Years in Practice	Mild	Moderate	Severe	Moderate & Severe	% Moderate & Severe	% Severe	(blank)	All
0_14	27	5	2	7	5.3%	1.5%	98	132
15_24	24	6	3	9	7.4%	2.5%	89	122
25_34	16	6	2	8	16.3%	4.1%	25	49
35_	12	9	2	11	20.8%	3.8%	30	53
(blank)	1	—	—	—	—	0.0%	1	2
Total	80	26	9	35	9.8%	2.5%	243	358

In the table above 2.5% of the 358 general dentists had "Severe" Hearing problems and 9.8% had "Moderate & Severe" problems. The trend described by the relationship of the *Interval for Years in Practice* and "Severe" (1.5%; 2.5%; 4.1% and 3.8%) was not strictly increasing (compare the last two rates). However, the trend described by "Moderate & Severe" (5.3%; 7.4%; 16.3% and 20.8%) was strictly increasing.

Table XXX

Frequency Table of *Severity Grading* and *Age Interval in Years* for those dentists who ever used the Airotor handpiece

	Severity Grading							
Age Interval in Years	Mild	Moderate	Severe	Moderate & Severe	% Moderate & Severe	% Severe	(blank)	All
<30	30	3	2	5	4.0%	1.6%	89	124
30_39	19	6	3	9	7.7%	2.6%	89	117
40_49	20	7	2	9	14.1%	3.1%	35	64
50_	11	10	2	12	23.5%	3.9%	28	51
(blank)	—	—	—	—	—	—	2	2
Total	80	26	9	35	9.8%	2.5%	243	358

In this table the same calculations were performed as in the previous table but the intervals were for *Age in Years.* As for the previous table, 2.5% of the 358 general dentists had "Severe" Hearing problems and 9.8% had "Moderate & Severe" problems. The trend described by the percentage "Severe" was strictly increasing (1.6%; 2.6%; 3.1% and 3.9%) in the relationship with the *Age Intervals*. The trend described by the percentage "Moderate & Severe" was also strictly increasing (4.0%; 7.7%; 14.1% and 23.5%) in the relationship with the *Age Intervals*.

The next two tables refer to the respondents who ever used Air Turbine handpieces.

Table XXX

Frequency Table of *Severity Grading* and *Interval for Years in Practice* for those dentists who ever used the Air Turbine handpiece

	Severity Grading							
Interval for Years in Practice	Mild	Moderate	Severe	Moderate & Severe	% Moderate & Severe	% Severity	(blank)	All
0_14	36	5	3	8	4.7%	1.7%	128	172
15_24	28	9	5	14	9.6%	3.4%	104	146
25_34	18	8	3	11	19.6%	5.4%	27	56
35_	13	9	2	11	20.4%	3.7%	30	54
(blank)	1	—	—	—	—	—	2	3
Total	96	31	13	44	10.2%	3.0%	291	431

In the table above 3.0% of the 431 general dentists had "Severe" Hearing problems and 10.2% had "Moderate & Severe" problems. Both these percentages were slightly higher than the rates associated with the Airotor users. The trend described by the relationship of the *Interval for Years in Practice* and "Severe" (1.7%; 3.4%; 5.4% and 3.7%) was not strictly increasing (compare the last two rates). However, the trend described by "Moderate & Severe" (4.7%; 9.6%; 19.6% and 20.4%) was strictly increasing.

Table XXX

Frequency Table of *Severity Grading* and *Age Interval in Years* for those dentists who ever used the Air Turbine handpiece

	Severity Grading							
Age Interval in Years	Mild	Moderate	Severe	Moderate &Severe	% Moderate & Severe	% Severe	(blank)	All
<30	39	3	3	6	3.7%	1.8%	118	163
30_39	22	8	4	12	8.5%	2.8%	107	141
40_49	22	9	5	14	19.4%	6.9%	36	72
50_	13	11	1	12	22.6%	1.9%	28	53
(blank)	—	—	—	—	—	—	2	2
Total	96	31	13	44	10.2%	3.0%	291	431

Problems and 10.2% had "Moderate & Severe" Problems. The trend described by the percentage "Severe" was not in the least strictly increasing (1.8%; 2.8%; 6.9% and 1.9%) in the relationship with the *Age Intervals*. However, the trend described by the percentage "Moderate & Severe" was strictly increasing (3.7%; 8.5%; 19.4% and 22.6%) in the relationship with the *Age Intervals*. Comparing these two sets of rates gave rise to an anomaly that did not show so starkly for the Airotor users (see the rates 2.8%; 6.9% and 1.9%; observe the sudden drop from 6.9% to 1.9%). The difference between the patterns of the "Severe" and the "Moderate & Severe" rates cannot be explained.

The next two tables refer to the respondents who ever used Ultrasonics handpieces.

Table XXX

Frequency Table of *Severity Grading* and *Interval for Years in Practice* for those dentists who ever used the Ultrasonincs handpiece

	Severity Grading							
Interval for Years in Practice	Mild	Moderate	Severe	Moderate & Severe	% Moderate & Severe	% Severe	(blank)	All
0_14	28	5	2	7	5.5%	1.6%	92	127
15_24	23	5	4	9	8.4%	3.7%	75	107
25_34	17	8	2	10	21.7%	4.3%	19	46
35_	8	8	2	10	27.0%	5.4%	19	37
(blank)	1	—	—	—	—	—	1	2
Total	77	26	10	36	11.3%	3.1%	206	319

Of the 319 Ultrasonics users 36 suffered from "Moderate & Severe" Hearing Problems. The trend of the proportion with "Severe" Hearing Problems for the *Interval for Years in Practice* was strictly increasing as well as the trend for the combined category "Moderate & Severe".

Of the respondents Ultrasonics users in the category "more than 34 years", 27.0% displayed "Moderate & Severe" Hearing Problems, the highest rate for the three handpieces.

Table XXX

Frequency Table of *Severity Grading* and *Age Interval in Years* for those dentists who ever used the Ultrasonics handpiece

	Severity Grading							
Age Interval in Years	Mild	Moderate	Severe	Moderate & Severe	% Moderate &Severe	%Severe	(blank)	All
<30	31	3	2	5	4.1%	1.6%	87	123
30_39	17	6	4	10	10.0%	4.0%	73	100
40_49	21	9	2	11	19.3%	3.5%	25	57
50_	8	8	2	10	26.3%	5.3%	20	38
(blank)	—	—	—	—	—	—	1	1
Total	77	26	10	36	11.3%	3.1%	206	319

The trend of the Ultrasonics users in relationship to the *Age Intervals* was not strictly increasing (1.6%; 4.0%; 3.5% and 5.3%) and displayed a different pattern compared to the other two handpieces. However, the trend for the "Moderate & Severe" category was strictly increasing. Of the Ultrasonics users in the category "more than 49 years of age", 26.3% displayed "Moderate & Severe" Hearing problems, the highest rate for the three handpieces.

In the next set of tables the character of the Hearing Problem such as *Did the problem occur suddenly or over an extended period?* will be discussed. "Blanks" with respect to this characteristic would not be mentioned in the tables to follow.

Table XXX

Frequency Table of *Did the problem occur suddenly or over an extended period* and *Interval for Years in Practice* for those dentists who ever used the Airotor handpiece

	Suddenly/Extended Period			
Interval for Years in Practice	Extended Period	Suddenly	% Extended Period	All
0_14	29	2	22.0%	132
15_24	25	6	20.5%	122
25_34	20	4	40.8%	49
35_	19	2	35.8%	53
(blank)	—	—	—	2
Total	93	14	26.0%	358

For all of the 358 general dentists who ever used the Airotor handpiece, 26.0% reported that their Hearing Problem occurred over an extended period, and only 14 (3.9%) said that their problem occurred suddenly. With these tables one would also like to investigate whether there was an increasing rate of certain characteristics e g "extended period". The characteristic "Suddenly" will not be studied in depth due to the low rate of occurrence. In the table above an increasing rate with regard to *Years in Practice* was observed, but it was not strictly increasing.

Table XXX

Frequency Table of *Did the problem occur suddenly or over an extended period* and *Age Interval in Years* for those dentists who ever used the Airotor handpiece

	Suddenly/Extended Period			
Age Interval in Years	Extended Period	Suddenly	% Extended Period	All
<30	27	3	21.8%	124
30_39	21	6	17.9%	117
40_49	26	2	40.6%	64
50_	19	3	37.3%	51
(blank)	—	—	—	2
Total	93	14	26.0%	358

The marginal rates of the table above is exactly the same as in the previous table; 26.0% reported that their Hearing problem occurred over an extended period, and only 14 (3.9%) said that their problem occurred suddenly, because the 358 respondents were the same individuals. The pattern of increase in relation to *Age Interval in Years* was approximately the same as *Years in Practice.*

Table XXX

Frequency Table of *Did the problem occur suddenly or over an extended period* and *Interval for Years in Practice* for those dentists who ever used the Air Turbine handpiece

	Suddenly/Extended Period			
Interval for Years in Practice	Extended Period	Suddenly	% Extended Period	All
0_14	35	4	20.3%	172
15_24	32	7	21.9%	146
25_34	24	5	42.9%	56
35_	21	2	38.9%	54
(blank)	—	—	—	3
Total	112	18	26.0%	431

For all of the 431 general dentists who ever used the Air Turbine handpiece 26.0% reported that their Hearing Problem occurred over an extended period, and only 18 (4.2%) said that their problem occurred suddenly. In the table above an increasing rate with regard to *Years in Practice* was observed, but it was not strictly increasing. The rates associated with the first two categories of *Years in Practice* (20.3% and 21.9%) were approximately the same; a small decrease of 4% occurred between the last two categories (42.9% and 38.9%), but it could also be seen as another plateau in the increase of the rates.

Table XXX

Frequency Table of *Did the problem occur suddenly or over an extended period* and *Age Interval in Years* for those dentists who ever used the Air Turbine handpiece

	Suddenly/Extended Period			
Age Interval in Years	Extended Period	Suddenly	% Extended Period	All
<30	33	5	20.2%	163
30_39	26	7	18.4%	141
40_49	33	3	45.8%	72
50_	20	3	37.7%	53
(blank)	—	—	—	2
Total	112	18	26.0%	431

The rates associated with the first two categories of *Age Interval in Years* (20.2% and 18.4%) were approximately the same; a decrease of 8.1% occurred between the last two categories (45.8% and 37.7%). The pattern of the increase in trend could be seen as consisting of two plateaux.

Table XXX

Frequency Table of *Did the problem occur suddenly or over an extended period* and *Interval for Years in Practice* for those dentists who ever used the Ultrasonics handpiece

	Suddenly/Extended Period			
Interval for Years in Practice	Extended Period	Suddenly	% Extended Period	All
0_14	29	3	22.8%	127
15_24	23	6	21.5%	107
25_34	23	4	50.0%	46
35_	17	—	45.9%	37
(blank)	—	—	—	2
Total	92	13	28.8%	319

For all 319 general dentists who ever used the Ultrasonics handpiece 28.8% (higher than for the Airotor and the Air Turbine handpieces) reported that their Hearing problem occurred over an extended period, and only 13 (4.1%) said that their problem occurred suddenly. In the table above an increasing rate with regard to *Years in Practice* was observed, but it was not strictly increasing. The rates associated with the first two categories of *Years in Practice* (22.8% and 21.5%) were approximately the same; a small decrease of 4.1% occurred between the last two categories (50.0% and 45.9%). In the pattern of the rates associated with *Years in Practice* two distinct plateaux occurred as before, but the second ended on a higher level compared to the other two handpieces.

Table XXX

Frequency Table of *Did the problem occur suddenly or over an extended period* and *Age Interval in Years* for those dentists who ever used the **Ultrasonics handpiece**

	Suddenly/Extended Period			
Age Interval in Years	Extended Period	Suddenly	% Extended Period	All
<30	27	4	22.0%	123
30_39	20	6	20.0%	100
40_49	29	2	50.9%	57
50_	16	1	42.1%	38
(blank)	—	—	—	1
Total	92	13	28.8%	319

The rates associated with the first two categories of *Age Interval in Years* (22.0% and 20.0%) were approximately the same; a decrease of 8.8% occurred between the last two categories (50.9% and 42.1%). From the pattern of the increase in rates it could be seen as consisting of two plateaux.

The characteristic of deafness to be *Unilateral or Bilateral* is discussed in the section to follow, and related to *Interval for Years in Practice* and *Age Interval in Years.* Being “Unilateral” was by far in the minority, varying between 7% and 9% of those using the three handpieces, and therefore more attention will be paid to the individuals complaining of “Bilateral” deafness.

Table XXX

Frequency Table of *Is it unilateral or bilateral?* and *Interval for Years in Practice* for those dentists who ever used the Airotor handpiece

	Unilateral/Bilateral				
Interval for Years in Practice	Bilateral	% Bilateral	Unilateral	% Unilateral	All
0_14	19	14.4%	12	9.1%	132
15_24	22	18.0%	8	6.6%	122
25_34	17	34.7%	3	6.1%	49
35_	14	26.4%	5	9.4%	53
(blank)	—	—	—	—	2
Total	72	20.1%	28	7.8%	358

For the users of the Airotor handpiece 20.1% had “Bilateral” deafness and 7.8% had “Unilateral” deafness. An increase occurred in the percentage “Bilateral” associated with *Interval for Years in Practice*, but the increase was not monotone (14.4%; 18.0%; 34.7% and 26.4%). The percentages “Unilateral” for the classes of *Years in Practice* described a U-shaped pattern.

Table XXX

Frequency Table of *Is it unilateral or bilateral?* and *Age Interval in Years* for those dentists who ever used the Airotor handpiece

	Unilateral/Bilateral				
Age Interval in Years	Bilateral	% Bilateral	Unilateral	% Unilateral	All
0_29	19	15.3%	12	9.7%	124
30_39	19	16.2%	7	6.0%	117
40_49	20	31.3%	3	4.7%	64
50_	14	27.5%	6	11.8%	51
(blank)	—	—	—	—	2
Grand Total	72	20.1%	28	7.8%	358

As with the *Intervals for Years in Practice* the increase of the percentage “Bilateral” was also not monotone with respect to *Age Intervals in Years*. The percentage “Unilateral” again described a U-shaped distribution for *Age Intervals in Years*.

Table XXX

Frequency Table of *Is it unilateral or bilateral?* and *Interval for Years in Practice* for those dentists who ever used the Air Turbine handpiece

	Unilateral/Bilateral				
Interval for Years in Practice	Bilateral	% Bilateral	Unilateral	% Unilateral	All
0_14	23	13.4%	18	10.5%	172
15_24	28	19.2%	11	7.5%	146
25_34	19	33.9%	5	8.9%	56
35_	17	31.5%	4	7.4%	54
(blank)	—	—	—	—	3
Total	87	20.2%	38	8.8%	431

For the users of the Air Turbine handpiece 20.2% had "Bilateral" deafness and 8.8% had "Unilateral" deafness. A definite increase occurred in the percentage "Bilateral" associated with *Interval for Years in Practice*, but the increase was not monotone (13.4%; 19.2%; 33.9% and 31.5%). The percentages "Unilateral" for the classes of *Years in Practice* did not show any clear pattern.

Table XXX

Frequency Table of *Is it unilateral or bilateral?* and *Age Interval in Years* for those dentists who ever used the Air Turbine handpiece

	Unilateral/Bilateral				
Age Interval in Years	Bilateral	% Bilateral	Unilateral	% Unilateral	All
1_age	23	14.1%	18	11.0%	163
2_age	23	16.3%	9	6.4%	141
3_age	24	33.3%	6	8.3%	72
4_age	17	32.1%	5	9.4%	53
(blank)	—	—	—	—	2
Grand Total	87	20.2%	38	8.8%	431

As with the *Intervals for Years in Practice* the increase of the percentage "Bilateral" was also not monotone with respect to *Age Intervals in Years*. The percentage "Unilateral" again described a weak U-shaped distribution for *Age Intervals in Years*.

Table XXX

Frequency Table of *Is it unilateral or bilateral?* and *Interval for Years in Practice* for those dentists who ever used the Ultrasonics handpiece

	Unilateral/Bilateral				
Interval for Years in Practice	Bilateral	% Bilateral	Unilateral	% Unilateral	All
0_14	20	15.7%	12	9.4%	127
15_24	23	21.5%	6	5.6%	107
25_34	18	39.1%	4	8.7%	46
35_	13	35.1%	2	5.4%	37
(blank)	—	—	—	—	2
Total	74	23.2%	24	7.5%	319

The percentage "Bilateral" showed an increase with relation to the *Interval for Years in Practice*; not monotone, but reached the highest rate (39.1%) for the 25-34 *Years in Practice interval.* This was the highest rate for any time interval (age or practice years) recorded for "Bilateral" deafness for the three handpieces. No definite pattern occurred in the "Unilateral" rates.

Table XXX

Frequency Table of *Is it unilateral or bilateral?* and *Age Interval in Years* for those dentists who ever used the Ultrasonics handpiece

	Unilateral/Bilateral				
Age Interval in Years	Bilateral	% Bilateral	Unilateral	% Unilateral	All
0_29	20	16.3%	12	9.8%	123
30_39	20	20.0%	5	5.0%	100
40_49	21	36.8%	4	7.0%	57
50_	13	34.2%	3	7.9%	38
(blank)	—	—	—	—	1
Total	74	23.2%	24	7.5%	319

As with the *Intervals for Years in Practice* the increase of the percentage "Bilateral" was also not monotone with respect to *Age Intervals in Years*. The percentage "Unilateral" again described a weak U-shaped distribution for *Age Intervals in Years.*

In the next set of six tables the influence of the three handpieces on the characteristic *Constant or Intermittent?* will be investigated.

Table XXX

Frequency Table of *Constant or Intermittent?* and *Interval for Years in Practice* for those dentists who ever used the Airotor handpiece

	Constant/Intermittent				
Interval for Years in Practice	Constant	% Constant	Intermittent	% Intermittent	All
0_14	16	12.1%	18	13.6%	132
15_24	19	15.6%	14	11.5%	122
25_34	18	36.7%	4	8.2%	49
35_	15	28.3%	5	9.4%	53
(blank)	1	—	—	—	2
Total	69	19.3%	41	11.5%	358

For the Airotor users the overall percentage of "Constant" Hearing Loss was 19.3% and those with an "Intermittent" problem, 11.5%. The trend of the proportion with a "Constant" problem was in general increasing but not strictly increasing. Strangely enough the percentage "Intermittent" was nearly strictly decreasing, but the rate of decrease was low.

Table XXX

Frequency Table of *Constant or Intermittent?* and *Age Interval in Years* for those dentists who ever used the Airotor handpiece

	Constant/Intermittent				
Age Interval in Years	Constant	% Constant	Intermittent	%Intermittent	All
<30	16	12.9%	19	15.3%	124
30_39	19	16.2%	9	7.7%	117
40_49	18	28.1%	9	14.1%	64
50_	16	31.4%	4	7.8%	51
(blank)	—	—	—	—	2
Total	69	19.3%	41	11.5%	358

The rate of increase of the percentage with a "Constant" Hearing Loss was monotone with respect to the *Age Intervals in Years*. However the percentage with an "Intermittent" problem fluctuated to a great extent in relation to *Age Intervals in Years.*

Table XXX

Frequency Table of *Constant or Intermittent?* and *Interval for Years in Practice* for those dentists who ever used the Air Turbine handpiece

	Constant/Intermittent				
Interval for Years in Practice	Constant	% Constant	Intermittent	% Intermittent	All
0_14	22	12.8%	21	12.2%	172
15_24	24	16.4%	18	12.3%	146
25_34	20	35.7%	6	10.7%	56
35_	15	27.8%	7	13.0%	54
(blank)	1	—	—	—	3
Total	82	19.0%	52	12.1%	431

For the Air Turbine users the overall percentage of "Constant" Hearing Loss was 19.0% and those with an "Intermittent" problem, 12.1%. The trend of the percentage with a "Constant" problem was in general increasing but not strictly increasing. The percentage "Intermittent" was nearly constant with relation to the *Years in Practice*.

Table XXX

Frequency Table of *Constant or Intermittent?* and *Age Interval in Years* for those dentists who ever used the Air Turbine handpiece

	Constant/Intermittent				
Age Interval in Years	Constant	% Constant	Intermittent	% Intermittent	All
<30	22	13.5%	22	13.5%	163
30_39	22	15.6%	12	8.5%	141
40_49	22	30.6%	11	15.3%	72
50_	16	30.2%	7	13.2%	53
(blank)	—	—	—	—	2
Total	82	19.0%	52	12.1%	431

The percentage "Constant" increased nearly monotone with respect to *Age Interval in Years* (13.5%; 15.6%; 30.6% and 30.2%). The percentage with an "Intermittent" problem fluctuated in relation to the *Age Intervals in Years.*

<u>Table XXX</u>

Frequency Table of *Constant or Intermittent?* and *Interval for Years in Practice* for those dentists who ever used the Ultrasonics handpiece

	Constant/Intermittent				
Interval for Years in Practice	Constant	% Constant	Intermittent	% Intermittent	All
0_14	18	14.2%	16	12.6%	127
15_24	16	15.0%	16	15.0%	107
25_34	18	39.1%	5	10.9%	46
35_	12	32.4%	4	10.8%	37
(blank)	1	—	—	—	2
Total	65	20.4%	41	12.9%	319

For the Ultrasonics users the overall percentage of "Constant" Hearing Loss was 20.4% and for those with an "Intermittent" problem, 12.9%. The trend of the proportion with a "Constant" problem was in general increasing but not strictly increasing. Strangely enough, the percentage "Intermittent" was nearly strictly decreasing, but the slope of the decrease was extremely low.

<u>Table XXX</u>

Frequency Table of *Constant or Intermittent?* and *Age Interval in Years* for those dentists who ever used the Ultrasonics handpiece,

	Constant/Intermittent				
Age Interval in Years	Constant	% Constant	Intermittent	% Intermittent	All
<30	18	14.6%	17	13.8%	123
30_39	17	17.0%	10	10.0%	100
40_49	18	31.6%	10	17.5%	57
50_	12	31.6%	4	10.5%	38
(blank)	—	—	—	—	1
Total	65	20.4%	41	12.9%	319

The trend of the percentage with a "Constant" problem was nearly strictly increasing. The percentage "Intermittent" was fluctuating with respect to the *Age Intervals in Years*.

To summarise the characteristics of the "Hearing Loss" and to compare it for the three handpieces used, the percentages were combined in the table below.

Table XXX

Comparison and Validation Table of the various characteristics: *b) Mild, Moderate or Severe; c) Suddenly or Extended Period; e) Unilateral or Bilateral; f) Constant or Intermittent*

Characteristic	Airotor	Air Turbine	Ultrasonics
Mild, Moderate and Severe – Combined	32.1%	32.5%	35.4%
Suddenly or Extended Period	29.9%	30.2%	32.9%
Unilateral or Bilateral	27.9%	29.0%	30.7%
Constant or Intermittent	30.7%	31.1%	33.2%
Any Hearing Loss	40.7%	40.1%	42.8%

There was hardly any difference in the percentage of the reported "Hearing Loss" for the users of Airotor, Air Turbine and Ultrasonics: respectively 40.7%; 40.1% and 42.8%. The proportions of the various characteristics did not differ to a great extent, but a noticeable increase occurred from Airotor to Air Turbine, and Air Turbine to Ultrasonics for all the characteristics. The possible slope differences with respect to *Years in Practice Intervals* and *Age Intervals in Years* were not investigated in depth, due to possible biases present in the data set, for example, that the likelihood to participate in this study depended on the severity of their "Hearing" problem. To understand the influence of the usage of the three handpieces was difficult because the data set did not contain any specific information on the period (time) that the users had worked with the three handpieces in their careers, and the possible combinations in which the three handpieces were used.

The respondents were asked to quantify *how Annoying their Hearing Problem was.* Of the selected group of general dentists, approximately 120 responded to this question while approximately 183 complained of Hearing Loss (between 40.8% and 42.9%). This indicated that more than seventy respondents who suffered from Hearing Loss did not reply to this question. Almost all respondents who stated the *Severity of their Hearing Problem* answered, on the scale 0 to 10, *How Annoying their Hearing Problem was.*

In the next six tables the descriptive statistics of the *Annoyance Rating* are provided for the twelve combined categories (twenty combined categories if the "blanks" of the two scales are taken into consideration) of *Years in Practice* and *Severity*; and *Age in Years* and *Severity* (two for each of the three handpieces). The following two tables are specifically for the Airotor users.

Table XXXX

Descriptive Statistics of the *Annoyance Rating* (on a scale 0 to 10) *of the Hearing Problem* according to *Severity* and *Interval for Years in Practice* for Airotor users

		Severity				
Interval for Years in Practice		Mild	Moderate	Severe	(blank)	All
0_14	Frequency of Qs	27	5	2	98	132
	Annoyance Rating Filled In	27	5	2		34
	Average of Annoyance Rating	2.6	4.8	4.0		3.0
	StdDev of A_Rating	1.39	0.84	5.66		1.80
	Min of A_Rating	0.5	4	0		0
	Max of A_Rating	6	6	8		8
15_24	Frequency of Qs	24	6	3	89	122
	Annoyance Rating Filled In	24	6	3		33
	Average of Annoyance Rating	2.5	5.5	7.0		3.5
	StdDev of A_Rating	1.53	1.22	1.73		2.18
	Min of A_Rating	0	5	5		0
	Max of A_Rating	5	8	8		8
25_34	Frequency of Qs	16	6	2	25	49
	Annoyance Rating Filled In	14	6	2	1	23
	Average of Annoyance Rating	2.9	5.0	8.5	2.0	3.9
	StdDev of A_Rating	1.44	0.89	0.71		2.11
	Min of A_Rating	1	4	8	2	1
	Max of A_Rating	6	6	9	2	9
35_	Frequency of Qs	12	9	2	30	53
	Annoyance Rating Filled In	10	9	2		21
	Average of Annoyance Rating	2.7	5.2	9.0		4.4
	StdDev of A_Rating	1.77	1.30	1.41		2.46
	Min of A_Rating	0	4	8		0
	Max of A_Rating	5	8	10		10
(blank)	Frequency of Qs	1			1	2
	Annoyance Rating Filled In	1				1
	Average of Annoyance Rating	3.0				3.0
	StdDev of A_Rating					
	Min of A_Rating	3				3
	Max of A_Rating	3				3
Total Frequency of Qs		80	26	9	243	358
Annoyance Rating Filled In		76	26	9	1	112
Average of Annoyance Rating		2.7	5.2	7.1	2.0	3.6
StdDev of A_Rating		1.47	1.08	2.98		2.13
Min of A_Rating		0	4	0	2	0
Max of A_Rating		6	8	10	2	10

Of the 112 respondents who filled in the *Annoyance Rating*, 111 also answered the question on the *Severity of their Hearing Problem*. The average *Annoyance Rating* of these 112 respondents was 3.6 and it was clear that they utilised the full scale (0 to 10). At the bottom of the above table the average *Annoyance Rating* of the "Mild" to "Severe" groups can be found; 2.7, 5.2 and 7.1; showing a strong increase as the *Severity* increases. The 111 who responded to the *Annoyance* question, displayed an increasing trend in their averages in relation to *Years in Practice* (3.0, 3.5, 3.9 and 4.4; refer to the right hand margin of the above table). In the inside of the table the bi-variate influence of both factors can be studied, but the frequency (or presence) of respondents decreases rapidly with the increase in *Severity* (see shaded areas). However, it was clear that the average *Annoyance Rating* was higher than expected, when the *Years in Practice* and *Severity* were in the higher classes.

Table XXXX

Descriptive Statistics of the *Annoyance Rating* (on a scale 0 to 10) *of the Hearing Problem* according to *Severity* and *Age Interval in Years* for Airotor users

		Severity				
Age Interval in Years		Mild	Moderate	Severe	(blank)	All
_29	Frequency of Qs	30	3	2	89	124
	Annoyance Rating Filled In	30	3	2		35
	Average of Annoyance Rating	2.6	5.0	4.0		2.8
	StdDev of A_Rating	1.40	1.00	5.66		1.80
	Min of A_Rating	0	4	0		0
	Max of A_Rating	6	6	8		8
30_39	Frequency of Qs	19	6	3	89	117
	Annoyance Rating Filled In	19	6	3		28
	Average of Annoyance Rating	2.5	5.5	7.0		3.6
	StdDev of A_Rating	1.43	1.22	1.73		2.20
	Min of A_Rating	1	5	5		1
	Max of A_Rating	5	8	8		8
40_49	Frequency of Qs	20	7	2	35	64
	Annoyance Rating Filled In	18	7	2	1	28
	Average of Annoyance Rating	2.8	4.9	8.5	2.0	3.7
	StdDev of A_Rating	1.62	0.90	0.71		2.12
	Min of A_Rating	0	4	8	2	0
	Max of A_Rating	6	6	9	2	9
50_	Frequency of Qs	11	10	2	28	51
	Annoyance Rating Filled In	9	10	2		21
	Average of Annoyance Rating	3.0	5.2	9.0		4.6
	StdDev of A_Rating	1.58	1.23	1.41		2.25
	Min of A_Rating	0	4	8		0
	Max of A_Rating	5	8	10		10
(blank)	Frequency of Qs				2	2
	Annoyance Rating Filled In					
	Average of Annoyance Rating					
	StdDev of A_Rating					
	Min of A_Rating					
	Max of A_Rating					
Total Count of No		80	26	9	243	358
Total Count of Rating		76	26	9	1	112
Total Average of Rating2		2.7	5.2	7.1	2.0	3.6
Total StdDev of Rating3		1.47	1.08	2.98		2.13
Total Min of Rating4		0	4	0	2	0
Total Max of Rating5		6	8	10	2	10

The 112 who responded to the *Annoyance* question displayed an increasing trend in their averages in relation to *Age in Years* (2.8, 3.6, 3.7 and 4.6; refer to the right hand margin of the above table). In the inside of the table the bi-variate influence of both factors can be studied, but the frequency of respondents decreases rapidly with the increase in *Severity* (see shaded areas). However, it was clear that the average *Annoyance Rating* was higher than expected, when the *Age in Years* and *Severity* were in the higher classes.

Table XXXX

Descriptive Statistics of the *Annoyance Rating* (on a scale 0 to 10) *of the Hearing Problem* according to *Severity* and *Interval for Years in Practice* for Air Turbine users

		Severity				
Interval for Years in Practice		Mild	Moderate	Severe	(blank)	All
0_14	Frequency of Qs	36	5	3	128	172
	Annoyance Rating Filled In	36	5	3		44
	Average of Annoyance Rating	2.4	4.8	5.7		2.9
	StdDev of A_Rating	1.34	0.84	4.93		1.95
	Min of A_Rating	0.5	4	0		0
	Max of A_Rating	6	6	9		9
15_24	Frequency of Qs	28	9	5	104	146
	Annoyance Rating Filled In	28	9	5		42
	Average of Annoyance Rating	2.5	5.1	6.8		3.6
	StdDev of A_Rating	1.48	1.54	1.64		2.16
	Min of A_Rating	0	2	5		0
	Max of A_Rating	5	8	8		8
25_34	Frequency of Qs	18	8	3	27	56
	Annoyance Rating Filled In	15	8	3	1	27
	Average of Annoyance Rating	2.8	5.3	8.0	2.0	4.1
	StdDev of A_Rating	1.47	1.04	1.00		2.20
	Min of A_Rating	1	4	7	2	1
	Max of A_Rating	6	7	9	2	9
35_	Frequency of Qs	13	9	2	30	54
	Annoyance Rating Filled In	11	9	2		22
	Average of Annoyance Rating	2.8	5.6	8.5		4.5
	StdDev of A_Rating	1.47	1.59	2.12		2.39
	Min of A_Rating	0	4	7		0
	Max of A_Rating	5	8	10		10
(blank)	Frequency of Qs	1			2	3
	Annoyance Rating Filled In	1				1
	Average of Annoyance Rating	3.0				3.0
	StdDev of A_Rating					
	Min of A_Rating	3				3
	Max of A_Rating	3				3
Total Frequency of Qs		96	31	13	291	431
Annoyance Rating Filled In		91	31	13	1	136
Average of Annoyance Rating		2.6	5.2	7.1	2.0	3.6
StdDev of A_Rating		1.40	1.31	2.56		2.19
Min of A_Rating		0	2	0	2	0
Max of A_Rating		6	8	10	2	10

Of the 136 Air Turbine users who filled in the *Annoyance Rating*, 135 also answered the question on the *Severity of their Hearing Problem*. A further five respondents provided an answer to the *Severity* scale, but not to the *Annoyance Rating* and 290 respondents had item non-responses for *Annoyance Rating* and the *Severity* scale. The average *Annoyance Rating* of these 136 respondents was 3.6 and it was clear that they utilised the full scale (0 to 10). At the bottom of the above table the average *Annoyance Rating* of the "Mild" to "Severe" groups can be found; 2.6, 5.2 and 7.1; showing a strong increase as the *Severity* increases. The 135 who responded to the *Annoyance* question, displayed an increasing trend in their averages in relation to *Years in Practice* 2.9, 3.6, 4.1 and 4.5; see the right hand margin of the above table). As before, the bi-variate influence of both factors can be studied in the inside of the table, but the frequency (or presence) of respondents decreases rapidly with the increase in *Severity* (see shaded areas). However, it was clear that the average *Annoyance Rating* was higher than expected, when the *Years in Practice* and *Severity* were in the higher classes. With respect to the assessment of the Airotor and the Air Turbine use and the influence thereof on *Hearing* through the averages of the *Annoyance Rating* the missing values (non-responses) prohibit an absolute comparison, but allow a relative evaluation.

Table XXXX

Descriptive Statistics of the *Annoyance Rating* (on a scale 0 to 10) *of the Hearing Problem* according to *Severity* and *Age Interval in Years* for Air Turbine users

		Severity				
Age Interval in Years		Mild	Moderate	Severe	(blank)	All
_29	Frequency of Qs	39	3	3	118	163
	Annoyance Rating Filled In	39	3	3		45
	Average of Annoyance Rating	2.4	5.0	5.7		2.8
	StdDev of A_Rating	1.35	1.00	4.93		1.94
	Min of A_Rating	0	4	0		0
	Max of A_Rating	6	6	9		9
30_39	Frequency of Qs	22	8	4	107	141
	Annoyance Rating Filled In	22	8	4		34
	Average of Annoyance Rating	2.6	5.0	6.5		3.6
	StdDev of A_Rating	1.37	1.60	1.73		2.05
	Min of A_Rating	1	2	5		1
	Max of A_Rating	5	8	8		8
40_49	Frequency of Qs	22	9	5	36	72
	Annoyance Rating Filled In	19	9	5	1	34
	Average of Annoyance Rating	2.8	5.1	7.8	2.0	4.1
	StdDev of A_Rating	1.50	1.05	0.84		2.23
	Min of A_Rating	1	4	7	2	1
	Max of A_Rating	6	7	9	2	9
50_	Frequency of Qs	13	11	1	28	53
	Annoyance Rating Filled In	11	11	1		23
	Average of Annoyance Rating	2.7	5.5	10.0		4.4
	StdDev of A_Rating	1.56	1.44			2.35
	Min of A_Rating	0	4	10		0
	Max of A_Rating	5	8	10		10
(blank)	Frequency of Qs				2	2
	Annoyance Rating Filled In	–				
	Average of Annoyance Rating	–				
	StdDev of A_Rating					
	Min of A_Rating					
	Max of A_Rating					
Total Count of No		96	31	13	291	431
Total Count of Rating		91	31	13	1	136
Total Average of Rating2		2.6	5.2	7.1	2.0	3.6
Total StdDev of Rating3		1.40	1.31	2.56		2.19
Total Min of Rating4		0	2	0	2	0
Total Max of Rating5		6	8	10	2	10

The 136 Air Turbine users who responded to the *Annoyance* question displayed an increasing trend in their averages in relation to *Age in Years* (2.8, 3.6, 4.1 and 4.4; refer to the right hand margin of the above table). As was the case in the previous three tables, this trend also displayed a monotone increase. In the inside of the table the bi-variate influence of both factors can be studied, but the frequency of respondents decreases rapidly with the increase in *Severity* (see shaded areas). However, it was clear that the average *Annoyance Rating* was higher than expected, when the *Age in Years* and *Severity* were in the higher classes.

Table XXXX

Descriptive Statistics of the *Annoyance Rating* (on a scale 0 to 10) *of the Hearing Problem* according to *Severity* and *Interval for Years in Practice* for Ultrasonics users

		Severity				
Interval for Years in Practice		Mild	Moderate	Severe	(blank)	All
0_14	Frequency of Qs	28	5	2	92	127
	Annoyance Rating Filled In	28	5	2		35
	Average of Annoyance Rating	2.3	4.8	4.0		2.8
	StdDev of A_Rating	1.27	0.84	5.66		1.78
	Min of A_Rating	0.5	4	0		0
	Max of A_Rating	5	6	8		8
15_24	Frequency of Qs	23	5	4	75	107
	Annoyance Rating Filled In	23	5	4		32
	Average of Annoyance Rating	2.3	5.0	6.5		3.3
	StdDev of A_Rating	1.56	2.12	1.73		2.25
	Min of A_Rating	0	2	5		0
	Max of A_Rating	5	8	8		8
25_34	Frequency of Qs	17	8	2	19	46
	Annoyance Rating Filled In	14	8	2	1	25
	Average of Annoyance Rating	2.9	5.3	7.5	2.0	4.0
	StdDev of A_Rating	1.29	1.04	0.71		1.93
	Min of A_Rating	1	4	7	2	1
	Max of A_Rating	5	7	8	2	8
35_	Frequency of Qs	8	8	2	19	37
	Annoyance Rating Filled In	7	8	2		17
	Average of Annoyance Rating	2.3	5.5	9.0		4.6
	StdDev of A_Rating	2.06	1.69	1.41		2.85
	Min of A_Rating	0	4	8		0
	Max of A_Rating	5	8	10		10
(blank)	Frequency of Qs	1			1	2
	Annoyance Rating Filled In	1				1
	Average of Annoyance Rating	3.0				3.0
	StdDev of A_Rating					
	Min of A_Rating	3				3
	Max of A_Rating	3				3
Total Frequency of Qs		77	26	10	206	319
Annoyance Rating Filled In		73	26	10	1	110
Average of Annoyance Rating		2.4	5.2	6.7	2.0	3.5
StdDev of A_Rating		1.43	1.41	2.79		2.21
Min of A_Rating		0	2	0	2	0
Max of A_Rating		5	8	10	2	10

Of the 110 Ultrasonics users who filled in the *Annoyance Rating*, 109 also answered the question on the *Severity of their Hearing Problem*. The average *Annoyance Rating* of these 110 respondents was 3.5 and it was clear that they utilised the full scale (0 to 10). At the bottom of the above table the average *Annoyance Rating* of the "Mild" to "Severe" groups can be found; 2.4, 5.2 and 6.7; showing a strong increase as the *Severity* increases. The 109 who responded to the *Annoyance* question, displayed an increasing trend in their averages in relation to *Years in Practice* 2.8, 3.3, 4.0 and 4.6; refer to the right hand margin of the above table). As before, the bi-variate influence of both factors can be studied in the inside of the table, but the frequency (or presence) of respondents decreases rapidly with the increase in *Severity* (see shaded areas). However, it was clear that the average *Annoyance Rating* was higher than expected, when the *Years in Practice* and *Severity* were in the higher classes.

Table XXXX

Descriptive Statistics of the *Annoyance Rating* (on a scale 0 to 10) *of the Hearing Problem* according to *Severity* and *Age Interval in Years* for Ultrasonics users

		Severity				
Age Interval in Years		Mild	Moderate	Severe	(blank)	All
_29	Frequency of Qs	31	3	2	87	123
	Annoyance Rating Filled In	31	3	2		36
	Average of Annoyance Rating	2.3	5.0	4.0		2.6
	StdDev of A_Rating	1.29	1.00	5.66		1.76
	Min of A_Rating	0	4	0		0
	Max of A_Rating	5	6	8		8
30_39	Frequency of Qs	17	6	4	73	100
	Annoyance Rating Filled In	17	6	4		27
	Average of Annoyance Rating	2.4	5.0	6.5		3.6
	StdDev of A_Rating	1.46	1.90	1.73		2.26
	Min of A_Rating	1	2	5		1
	Max of A_Rating	5	8	8		8
40_49	Frequency of Qs	21	9	2	25	57
	Annoyance Rating Filled In	18	9	2	1	30
	Average of Annoyance Rating	2.8	5.1	7.5	2.0	3.8
	StdDev of A_Rating	1.52	1.05	0.71		1.98
	Min of A_Rating	0	4	7	2	0
	Max of A_Rating	5	7	8	2	8
50_	Frequency of Qs	8	8	2	20	38
	Annoyance Rating Filled In	7	8	2		17
	Average of Annoyance Rating	2.4	5.5	9.0		4.6
	StdDev of A_Rating	1.90	1.69	1.41		2.76
	Min of A_Rating	0	4	8		0
	Max of A_Rating	5	8	10		10
(blank)	Frequency of Qs				1	1
	Annoyance Rating Filled In	–				
	Average of Annoyance Rating	–				
	StdDev of A_Rating					
	Min of A_Rating					
	Max of A_Rating					
Total Count of No		77	26	10	206	319
Total Count of Rating		73	26	10	1	110
Total Average of Rating2		2.4	5.2	6.7	2.0	3.5
Total StdDev of Rating3		1.43	1.41	2.79		2.21
Total Min of Rating4		0	2	0	2	0
Total Max of Rating5		5	8	10	2	10

The 110 Ultrasonics users who responded to the *Annoyance* question displayed an increasing trend in their averages in relation to *Age in Years* (2.6, 3.6, 3.8 and 4.6; see the right hand margin of the above table). As was the case in the previous three tables, this trend also displayed a monotone increase. In the inside of the table the bi-variate influence of both factors can be studied, but the frequency of respondents decreases rapidly with the increase in *Severity* (see shaded areas). However, it was clear that the average *Annoyance Rating* was higher than expected, when the *Age in Years* and *Severity* were in the higher classes. With respect to the assessment of the Airotor, Air Turbine and Ultrasonics use and the influence thereof on *Hearing* through the averages of the *Annoyance Rating* the missing values (non-responses) prohibit an absolute comparison, but allows a relative evaluation of the three handpieces.

In the six tables to follow the relationship between the presence of *Sleep Disturbance* and *Years in Practice* as well as *Age in Years* will be discussed.

Table XXX

Frequency Table of *Is there any sleep disturbance e g falling asleep or being woken during the night and possibly not being able to fall asleep again; single or multiple sound or noises?* and *Years in Practice* for those dentists who ever used the Airotor handpiece

Count of No	Sleep Disturbance			
Interval for Years in Practice	No	Yes	% Sleep Disturbance	All
0_14	33	5	3.8%	132
15_24	32	5	4.1%	122
25_34	16	7	14.3%	49
35_	19	2	3.8%	53
(blank)		1	—	2
Total	100	20	5.6%	358

Of the 358 users of the Airotor handpiece 5.6% had *Sleep Disturbances,* but the trend described by the different classes of *Years in Practice* was fluctuating extensively. It was interesting to observe that 14.3% of the respondents in the '25 to 34 year' interval, experienced *Sleep Disturbances.*

Table XXX

Frequency Table of *Is there any sleep disturbance e g falling asleep or being woken during the night and possibly not being able to fall asleep again; single or multiple sound or noises?* and *Age in Years* for those dentists who ever used the Airotor handpiece

	Sleep Disturbance			
Age Interval in Years	No	Yes	% Sleep Disturbance	All
<30	33	6	4.8%	124
30_39	26	5	4.3%	117
40_49	21	8	12.5%	64
50_	19	1	2.0%	51
(blank)	1			2
Total	100	20	5.6%	358

The trend described by the different classes of *Age in Years* was fluctuating extensively. It was interesting to observe that 12.5% of the respondents in the '40 to 49 year' age interval, experienced *Sleep Disturbances*

Table XXX

Frequency Table of *Is there any sleep disturbance e g falling asleep or being woken during the night and possibly not being able to fall asleep again; single or multiple sound or noises?* and *Years in Practice* for those dentists who ever used the Air Turbine handpiece

Count of No	Sleep Disturbance			
Interval for Years in Practice	No	Yes	% Sleep Disturbance	All
0_14	45	5	2.9%	172
15_24	39	7	4.8%	146
25_34	20	7	12.5%	56
35_	20	4	7.4%	54
(blank)		1		3
Total	124	24	5.6%	431

Of the 431 users of the Air Turbine handpiece 5.6% had *Sleep Disturbances,* but the trend described by the different classes of *Years in Practice* was fluctuating extensively. Of the respondents in the '25 to 34 year' interval, 12.5% experienced *Sleep Disturbances.*

Table XXX

Frequency Table of *Is there any sleep disturbance e g falling asleep or being woken during the night and possibly not being able to fall asleep again; single or multiple sound or noises?* and *Age in Years* for those dentists who ever used the Air Turbine handpiece

	Sleep Disturbance			
Age Interval in Years	No	Yes	% Sleep Disturbance	All
<30	45	7	4.3%	163
30_39	31	5	3.5%	141
40_49	25	10	13.9%	72
50_	22	2	3.8%	53
(blank)	1			2
Total	124	24	5.6%	431

The trend described by the different classes of *Age in Years* was fluctuating extensively. Of the respondents in the '40 to 49 year' age interval, 13.9% experienced *Sleep Disturbances.*

Table XXX

Frequency Table of *Is there any sleep disturbance e.g. falling asleep or being woken during the night and possibly not being able to fall asleep again; single or multiple sound or noises?* and *Years in Practice* for those dentists who ever used the Ultrasonics handpiece

Count of No	Sleep Disturbance			
Interval for Years in Practice	No	Yes	% Sleep Disturbance	All
0_14	35	5	3.9%	127
15_24	31	5	4.7%	107
25_34	20	5	10.9%	46
35_	14	3	8.1%	37
(blank)		1		2
Total	100	19	6.0%	319

Of the 319 users of the Ultrasonics handpiece 6.0% had *Sleep Disturbances,* but the trend described by the different classes of *Years in Practice* was fluctuating. Of the respondents in the '25 to 34 year' interval, 10.9% experienced *Sleep Disturbances.*

Table XXX

Frequency Table of *Is there any sleep disturbance e g falling asleep or being woken during the night and possibly not being able to fall asleep again; single or multiple sound or noises?* and *Age in Years* for those dentists who ever used the Ultrasonics handpiece

	Sleep Disturbance			
Age Interval in Years	No	Yes	% Sleep Disturbance	All
<30	35	7	5.7%	123
30_39	26	4	4.0%	100
40_49	24	6	10.5%	57
50_	15	2	5.3%	38
(blank)				1
Total	100	19	6.0%	319

The rates in the different classes of *Age in Years* were fluctuating. Of the respondents in the '40 to 49 year' age interval, 10.5% experienced *Sleep Disturbances.*

In the next section (consisting of six tables) the *Need to seek Medical Help e g ENT, Otologist, Audiologist?* and *Interval for Years in Practice* and *Age Interval in Years* will be investigated.

Table XXX

Frequency Table of *Ever necessary to seek Medical Help e.g. ENT, Otologist, Audiologist?* and *Interval for Years in Practice* for those dentists who ever used the Airotor handpiece

	Medical Help			
Interval for Years in Practice	No	Yes	% Medical Help	All
0_14	104	16	12.1%	132
15_24	97	17	13.9%	122
25_34	38	5	10.2%	49
35_	34	15	28.3%	53
(blank)	2	—	—	2
Total	275	53	14.8%	358

The percentage of the general dentists who ever used the Airotor handpiece (358) who needed *Medical Help* was 14.8%. An increasing proportion of these dentists, with respect to *Years in Practice,* needed *Medical Help*. This rate was more or less constant for the first three intervals and thereafter increased suddenly to 28.3%.

Table XXX

Frequency Table of *Ever necessary to seek Medical Help e.g. ENT, Otologist, Audiologist?* and *Age Interval in Years* for those dentists who ever used the Airotor handpiece

	Medical Help			
Age Interval in Years	No	Yes	% Medical Help	All
<30	96	17	13.7%	124
30_39	95	14	12.0%	117
40_49	53	5	7.8%	64
50_	30	17	33.3%	51
(blank)	1	—	—	2
Total	275	53	14.8%	358

The percentage of the general dentists who ever used the Airotor handpiece (358 individuals) who needed *Medical Help* was 14.8% (this is exactly the same as for the table above (mandatory, due to the construction of the tables)). An increasing proportion of these dentists, with respect to *Age in Years,* needed *Medical Help*. This rate was decreasing for the first three intervals and thereafter increased dramatically to 33.3%.

Table XXX

Frequency Table of *Ever necessary to seek Medical Help e.g. ENT, Otologist, Audiologist?* and *Interval for Years in Practice* for those dentists who ever used the Air Turbine handpiece

	Medical Help			
Interval for Years in Practice	No	Yes	% Medical Help	All
0_14	136	19	11.0%	172
15_24	116	21	14.4%	146
25_34	44	7	12.5%	56
35_	35	16	29.6%	54
(blank)	2	1	—	3
Total	333	64	14.8%	431

The general dentists who ever used the Air Turbine handpiece (431 individuals) who needed *Medical Help,* was 14.8%. An increasing proportion of these dentists, with respect to *Years in Practice,* needed *Medical Help.* This rate was more or less constant for the first three intervals and thereafter increased suddenly to 29.6%.

Table XXX

Frequency Table of *Ever necessary to seek Medical Help e.g. ENT, Otologist, Audiologist?* and *Age Interval in Years* for those dentists who ever used the Air Turbine handpiece

	Medical Help			
Age Interval in Years	No	Yes	% Medical Help	All
<30	127	20	12.3%	163
30_39	115	17	12.1%	141
40_49	58	9	12.5%	72
50_	32	18	34.0%	53
(blank)	1	—	—	2
Total	333	64	14.8%	431

The percentage of the general dentists who ever used the Air Turbine handpiece (431 individuals) who needed *Medical Help* was 14.8% (this is exactly the same as for the table above (mandatory, due to the construction of the tables)). An increasing proportion of these dentists, with respect to *Age in Years,* needed *Medical Help.* The pattern of this rate was more or less constant for the first three intervals and thereafter increased dramatically to 34.0%.

Table XXX

Frequency Table of *Ever necessary to seek Medical Help e.g. ENT, Otologist, Audiologist?* and *Interval for Years in Practice* for those dentists who ever used the Ultrasonics handpiece

	Medical Help			
Interval for Years in Practice	No	Yes	% Medical Help	All
0_14	101	14	11.0%	127
15_24	84	16	15.0%	107
25_34	35	6	13.0%	46
35_	21	13	35.1%	37
(blank)	2	—	—	2
Total	243	49	15.4%	319

The general dentists who ever used the Ultrasonics handpiece (319 individuals) who needed *Medical Help,* was 15.4%. An increasing proportion of these dentists, with respect to *Years in Practice,* needed *Medical Help.* This rate was more or less constant for the first three intervals and thereafter increased suddenly to 35.1%.

Table XXX

Frequency Table of *Ever necessary to seek Medical Help e.g. ENT, Otologist, Audiologist?* and *Age Interval in Years* for those dentists who ever used the Ultrasonics handpiece

	Medical Help			
Age Interval in Years	No	Yes	% Medical Help	All
<30	97	15	12.2%	123
30_39	79	14	14.0%	100
40_49	46	6	10.5%	57
50_	21	14	36.8%	38
(blank)	—	—	—	1
Total	243	49	15.4%	319

The percentage of the general dentists who ever used the Ultrasonics handpiece (319 individuals) who needed *Medical Help* was 15.4% (this is exactly the same as for the table above (mandatory, due to the construction of the tables)). An increasing proportion of these dentists, with respect to *Age in Years,* needed *Medical Help.* The pattern of this rate was more or less constant for the first three intervals and thereafter increased dramatically to 36.8%.

Table XXX

Frequency Table of *Ever had an Audiogram?* and *Interval for Years in Practice* for those dentists who ever used the Airotor handpiece

	Audiogram			
Interval for Years in Practice	No	Yes	% Audiogram	All
0_14	105	19	14.4%	132
15_24	90	26	21.3%	122
25_34	36	10	20.4%	49
35_	33	17	32.1%	53
(blank)	2	—	—	2
Total	266	72	20.1%	358

In the table above 20.1% of the 358 respondents who ever used the Airotor handpiece had an *Audiogram*. The trend described by the rates in the different classes of *Years in Practice* was increasing.

Table XXX

Frequency Table of *Ever had an Audiogram?* and *Age Interval in Years* for those dentists who ever used the Airotor handpiece

	Audiogram			
Age Interval in Years	No	Yes	% Audiogram	All
<30	98	18	14.5%	124
30_39	88	24	20.5%	117
40_49	50	10	15.6%	64
50_	29	20	39.2%	51
(blank)	1	—	—	2
Total	266	72	20.1%	358

The trend described by the percentage respondents who had an *Audiogram* was increasing (14.5%, 20.5%, 15.6% and 39.2%). The percentage of respondents in the age interval 50 years and older, who had an *Audiogram* was very high, namely 39.2%.

Table XXX

Frequency Table of *Ever had an Audiogram?* and *Interval for Years in Practice* for those dentists who ever used the Air Turbine handpiece

	Audiogram			
Interval for Years in Practice	No	Yes	% Audiogram	All
0_14	141	23	13.4%	172
15_24	109	31	21.2%	146
25_34	38	15	26.8%	56
35_	35	16	29.6%	54
(blank)	2	1	—	3
Grand Total	325	86	20.0%	431

In the table above 20.0% of the 431 respondents who ever used the Air Turbine handpiece had an *Audiogram.* The trend described by the rates in the different classes of *Years in Practice* was strictly increasing.

Table XXX

Frequency Table of *Ever had an Audiogram?* and *Age Interval in Years* for those dentists who ever used the Air Turbine handpiece

	Audiogram			
Age Interval in Years	No	Yes	% Audiogram	All
<30	133	22	13.5%	163
30_39	108	28	19.9%	141
40_49	51	17	23.6%	72
50_	32	19	35.8%	53
(blank)	1	—	—	2
Grand Total	325	86	20.0%	431

The trend described by the percentage respondents who had an *Audiogram* was strictly increasing (13.5%, 19.9%, 23.6% and 35.8%).

Table XXX

Frequency Table of *Ever had an Audiogram?* and *Interval for Years in Practice* for those dentists who ever used the Ultrasonics handpiece

	Audiogram			
Interval for Years in Practice	No	Yes	% Audiogram	All
0_14	106	16	12.6%	127
15_24	81	22	20.6%	107
25_34	30	13	28.3%	46
35_	19	15	40.5%	37
(blank)	2	—	—	2
Grand Total	238	66	20.7%	319

In the table above 20.7% of the 319 respondents who ever used the Ultrasonics handpiece had an *Audiogram*. The trend described by the rates in the different classes of *Years in Practice* was strictly increasing.

Table XXX

Frequency Table of *Ever had an Audiogram?* and *Age Interval in Years* for those dentists who ever used the Ultrasonics handpiece

	Audiogram			
Age Interval in Years	No	Yes	% Audiogram	All
<30	102	16	13.0%	123
30_39	77	20	20.0%	100
40_49	40	13	22.8%	57
50_	19	17	44.7%	38
(blank)	—	—	—	1
Grand Total	238	66	20.7%	319

The trend described by the percentage respondents who had an *Audiogram* was strictly increasing (13.0%, 20.0%, 22.8% and 44.7%).

In situ measurement of the loudness of various turbines

The author obtained *in situ* measurements of the noise made by various brand-name handpieces used in approximately 31 dental practices. This was largely a convenience sample and the results obtained in this limited survey were classified according to the brand-names of the handpieces. To gain some insight into the distribution of the loudness as measured in decibels it was displayed in Stem-and-Leaf diagrams. For readers not knowledgeable on statistical graphics a short explanation of the Stem-and-Leaf diagram will be provided.

The first characteristic of a Stem-and-leaf diagram is that it summarises the sample values from smallest to largest (ascending order). In the case of the decibel measurements of the turbines (drills), the Stem-and-leaf method ranks the measurements from the less loud (top) to the loudest (bottom). Studying the first column in Figure 1 (the Kavo turbine) it could be observed that the most quiet turbine had a loudness measurement of 60 decibels (dB) and the second most quiet turbine had a measurement of 64 dB. The three loudest Kavo turbines measured 78dB, 77dB and 76dB respectively. The mean loudness of the 27 Kavo turbines measured was 72.2 dB and the median was 72 dB (see the descriptive statistics below each diagram). This indicated that the distribution of these measurements was reasonably symmetrical, as could also be observed from the particular Stem-and-leaf diagram.

The second and third column of Figure 1 represent the loudness measurements made for the ***Midwest*** and ***NSK*** turbines, respectively. The four diagrams below the title of Figure 1 represent the loudness measurements made for the ***W&H, Siemens, Sirona*** and the ***old*** turbines, respectively.

Decibel Measurements
Kavo

Stem	*Leaves*
6	04
6	889
7	00012 22222 4444
7	55567 888
8	
8	
9	
9	
10	
10	

Decibel Measurements
Midwest

Stem	*Leaves*
6	2
6	88
7	22224 44
7	56
8	
8	
9	
9	
10	
10	

Decibel Measurements
NSK

Stem	*Leaves*
6	4
6	78889
7	00222 223
7	55668
8	
8	
9	
9	
10	
10	

	Kavo	Midwest	NSK
Minimum	60	62	64
Average	72.2	71.6	71.4
Median	72	72	72
Maximum	78	76	78

Figure 1 (above and below)
Stem-and-Leaf Diagram of Decibel Measurements of the various Handpieces (Brand names indicated); This sample consists of 79 different handpieces selected from participating practices.

Decibel Measurements
W&H

Stem	*Leaves*
6	2
6	55
7	
7	
8	
8	
9	
9	
10	
10	

Decibel Measurements
Siemens

Stem	*Leaves*
6	
6	5888
7	
7	
8	
8	
9	
9	
10	
10	

Decibel Measurements
Sirona

Stem	*Leaves*
6	0024
6	66
7	2
7	
8	
8	
9	
9	
10	
10	

Decibel Measurements
Old Machines

Stem	*Leaves*
6	
6	
7	
7	89
8	22
8	67
9	
9	
10	0
10	

	W&H	Siemens	Sirona	Old Machines
Minimum	62	65	60	78
Average	64.0	77.3	64.3	84.9
Median	65	68	64	82
Maximum	65	68	72	100