Osteopathy and Tinnitus

Master Thesis for the academic degree
Master of Science in Osteopathy

Donau Universität Krems

Presented to
Wiener Schule für Osteopathie

Martina Plamberger

Vienna, December 2006

Coordinated by: Mag. Katharina Musil

EIDESSTATTLICHE ERKLÄRUNG

Hiermit versichere ich, die vorgelegte Masterthese selbständig verfasst zu haben.

Alle Stellen, die wörtlich oder sinngemäß aus veröffentlichten oder nicht veröffentlichten Arbeiten anderer übernommen wurden, wurden als solche gekennzeichnet. Sämtliche Quellen und Hilfsmittel, die ich für diese Arbeit genützt habe, sind angegeben. Die Arbeit hat mit gleichem Inhalt noch keiner anderen Prüfungsbehörde vorgelegen.

- -

Datum | Unterschrft

In loving memory.
Dedicated to my father, Engelbert Spachinger

Abstract

This osteopathic study on patients with the tinnitus symptom discusses whether general osteopathic treatment according to the principles of Still (osteopathic group), in comparison to the progressive muscle relaxation of Jacobson (control group), can immediately influence tinnitus in its intensity, pitch, discomfort and character, and how the long-term effect after 6 weeks is to be evaluated.

Tinnitus has emerged as a warning sign of an extreme situation. It has been established that nearly all tinnitus patients (90%) examined in this study have an extensive tension in dura mater or inner fascia along the central axis which is shown in a membranous imbalance in the tentorium cerebelli and in rotation lesions of temporal bone. It is interesting that a release of the vessel system through a release in dural, fascial and visceral structures can influence or even eliminate the tinnitus symptom.

This study shows that osteopathy can influence tinnitus in its intensity and subjective discomfort mainly in the acute stage, while the pitch and character of tinnitus are barely changeable. Osteopathy can certainly be regarded as a gentle method of relieving an extreme situation so that the patient recognises his or her own limits and can return to health.

Table of contents

1. Introduction

Tinnitus is a steadily increasing symptom in today’s society. According to the German Tinnitus-Liga (2003) about eight per cent of German adults and already over five per cent of juveniles and young adults up to 29 years of age are affected by tinnitus. The psychological strain due to the “loss of silence” is enormous. (Janda, 2006)

1.1 Purpose of the study

The objective of this study is to find out if general osteopathic therapy can directly affect ringing in the ears (tinnitus) in intensity, pitch, discomfort and character.

1.2 Hypothesis

General osteopathic therapy can directly affect tinnitus in intensity, pitch, discomfort and character.

2. Tinnitus

2.1 Definition

Tinnitus is a ringing in the ears which is heard by the patient either in one ear, in both ears or in the head. According to patients it can sound like a whistle, rushing, cracking, humming, roaring, droning and many other noises. Ringing in the ears is regarded as abnormal auditory information caused by a dysfunction in or around the hearing system (Boenninghaus/Lenarz, 2005, p. 118)

2.2 Medical records regarding tinnitus

The research of Feldmann (1998) regarding tinnitus shows that this phenomenon is not a "modern symptom" of our fast-paced consumer society.

The oldest written documents found regarding tinnitus come from ancient Egypt. The Ebers papyrus originating from the 17th dynasty (1650-1532 BC) describes the treatment of "jinxed" or "bewitched" ears. In Ayur-Veda, the book of mythical Susruta, a collection of ancient Indian medical knowledge, tinnitus was first associated with deafness. It also states that tinnitus is a symptom of sensorial dysfunction and indication of approaching confusion and hallucination. Hippocrates (460-377 BC), Aristotle (384-322 BC) and Celsus (around 30 AD) do not describe tinnitus and deafness as an independent symptom either. Instead they always indicate it to be parts of symptom complexes, but most of all it is deemed to be a signal which characterises an alarming pre-collaptic or pre-final condition.

Galen (129-199 AD) used the expression of "échos" with the opinion that ascending vapours from the stomach harm the hearing organ, and can also cause impaired vision. He is the first one to describe that not only the cold, heat, accidents, an upset stomach and intense vomiting promote tinnitus, but it can also appear as a consequence of using local "ototoxic" mixtures. His twenty formulas against buzzing in the ears were used for more than one and a half millennia. Even Beethoven treated his ears with almond oil on his doctor's advice.

During the Renaissance period medical and natural scientists started to examine the human body more thoroughly. New anatomical findings described by Vesalius (1543) and Paracelsus (1491-1541) did not contribute to solving the problem of tinnitus.

In the 17th century Duverney (1648-1730) started to compile a classification for tinnitus. He described the difference between objective und subjective tinnitus which is still valid without restriction.

In the 19th century, the age of industrialisation, it was found that extreme noise can affect, or even permanently destroy the sense of hearing. At this time Grapengießer experimented with electrical applications to treat tinnitus. These methods had only little success. Nowadays, new developments in electrical treatment methods for tinnitus and the usage of cochlear implants show encouraging results.

Itard (1821) described the finding that external masking sounds are a lot easier to bear compared to the non-escapable inner sounds of tinnitus. Thus an attempt was made to reduce these noises by the use of hearing aids. Nowadays, the so called “masker” is regarded as a promising approach, where masking is used to distract the nervous system.

Famous people such as Martin Luther (1483-1546), Jean-Jacques Rousseau (1712-1778), Ludwig van Beethoven (1770-1827) and Bedrich Smetana (1824-1884) expressed their desperation and sorrow caused by tinnitus repeatedly in their literature and music. (Feldmann, 1998, p. 1-30)

In the Middle Ages the sense of hearing played a significant role because the ear was the entrance to the soul. These days the eye has taken over this role. Indeed if stimulus becomes excessive, the eye can close to relax, unlike the hearing organ which cannot be simply “switched off”. (Plothe, 2006, p. 25)

To this day, in times of highly intensive research, the pathophysiology of tinnitus can essentially only be based on hypothesis.

2.3. Classification

According to the guidelines of The German Society of ENT Medicine (1998) a classification by history of origins, location of cause, progress and severity of tinnitus can be made (cf. AWMF online)

2.3.1 History of origins: objective – subjective

Objective tinnitus is caused by a sound source within the body close to the ears, where the sound emission is audible, e.g. caused by vascular and muscular processes or noises through breathing. (Boenninghaus/Lenarz, 2005, p. 118)

Subjective tinnitus (tinnitus aurium) is caused by deficient information processing in the auditory system without influence of an acoustic stimulation. Very often this ringing in the ears arises due to deafness from impairment of sensorial cells, e.g. acoustic trauma (Boennighaus/Lenarz, 2005, p. 118-119)

2.3.2 Location of cause

A classification also can be made by establishing the location of injury by audiometric top diagnostic studies. Deficient hearing sensations can result from a problem in the auricle, tympanum (conductive tinnitus), internal ear (cochlear tinnitus), up to the central auditory system (neural tinnitus). (Feldmann, 1998, p. 51, 106-108) This type of classification is very significant for the differential diagnosis and subsequent therapy. (Feldmann, 1998, p. 87)
A more detailed consideration follows in chapter 3, section 3.2. – 3.5.

2.3.3 Progress: acute – subacute – chronic

Acute tinnitus exists from the first appearance to a maximum of three months. There is an acute, but potentially reversible dysfunction of hair cells similar to acute hearing loss or deafness by shock waves. The orthodox medicine rapidly prescribes rheological infusion therapy or hyperbaric oxygen therapy. (Feldmann, 1998, p. 84-86)

The subacute tinnitus is the time frame between three months and one year. A dysfunction of hair cells has become manifest, therefore a complete disappearance of the sound can no longer be expected. (Feldmann, 1998, p. 86)

If the ringing in the ears persists for more than a year then it is referred to as chronic tinnitus. In this case irreversible damage occurs, therefore therapy methods around secondary symptomatology such as psychotherapy, retraining therapy and hearing aid adaptations are mostly preferred. (Feldmann, 1998, p. 86-87)

2.3.4 Secondary symptomatology: compensated – decompensated

Compensated tinnitus:

If the patient can detect the ringing in the ears, but secondary symptomatologies are not present, it is called a compensated tinnitus. The patient can live and deal rationally with tinnitus, therefore no or only little suffering exists. The quality of life is not essentially affected. (cf. AWMF online)

Grade 1: Compensated tinnitus: the patient detects tinnitus, but it can be faded into the background. There is no suffering.

Grade 2: Mostly the tinnitus appears during silence and is a disturbing factor in stress or psycho-physical stress situations.

Decompensated tinnitus:

Decompensated tinnitus has severe consequences in all aspects of life and leads to the development of secondary symptomatologies, such as insomnia, lack of concentration, anxiety neurosis or depression. There is tremendous suffering. The impact on the quality of life is considerable. (Feldmann, 1998, p. 87)

Grade 3: Tinnitus causes constant disturbance in both private and professional situations. Disturbances occur in the emotional, cognitive and physical areas.

Grade 4: Tinnitus causes complete private decompensation. It affects the entire sensorial perception and orientation. The patient is depressive, escapes into social isolation, grows lonely and is at risk of committing suicide.

2.4. History of origins and concurrent causes

2.4.1 Subjective tinnitus

Subjective tinnitus based on abnormal coding of auditory information can be caused by damage on different levels, such as cochlear lesions, spontaneous activity of degenerated nerve fibre with emphatic transmissions at the cochlear nerve and central auditory damage. (Goebel, 2001, p. 19)

A cochlear lesion is assumed to be damage to the sensory hair cells of different origins. Damaged outer hair cells execute ebullient contractions, which mean that the inner hair cells cannot be stimulated optimally. Furthermore an abnormal distribution of certain ions, defects in enzyme systems, which control the metabolism processes, etc., as a result of permanent leakage, may cause permanent discharge of transmitter quanta into the synaptic fissure. This results in a permanent change in time succession of action potential, which is produced in the afferent hearing nerve tracts. (Goebel, 2001, p. 21)

After the destruction of hair cells an advancing degeneration of nerve fibre sets in. Electrically unstable points develop, triggering action potential that can be transmitted to adjacent fibre, comparable to phantom limb pain in amputated extremities. This causes rhythmic stimulations between these adjacent fibres, but there is a generation of circling repeating excitations in the central hearing tracts. This permanent action potential causes an incorrect input to the central auditory system. In good health the sequences are stochastic, which the auditory system interprets as silence. But if there is a deviation from this stochastic pattern, it is synonymous with the code for an acoustic signal. The brain interprets this discharge caused by spontaneous activity as an audible impression. Depending on the extent it effectuates different subjective impressions, such as rushing or whistling. The tinnitus develops a persistence that remains, even after the elimination of cochlear causes or transaction of the auditory nerve. (Goebel, 2001, p. 21-24, 31)

It can be assumed that the persistence of the subjective chronic tinnitus is not developed by a local cause, but there is an integration of the sound by central auditory processing and adaptations. (Dräger, 2000, p. 4)

The real point of origin may also be situated in the auditory cortex, where the limbic system seems to play the role of an amplifier by being a neurological substrate of emotional processes. (Hellbrück/Ellermeier, 2004, p. 207) It is assumed that the limbic system is involved in the origin and maintenance of emotional reactions, probably of the memory. Furthermore, hypothetical connections to the hearing tract are described. (Goebel, 2001, p. 312) The patient quickly notices this discrepancy between the lacking external sound occurrence and the permanent tinnitus. Because of the negative process of amplification, there is a development of secondary factors (stress, tension, insomnia, fear, depression). (Goebel, 2001, p. 22-23)

Possible causes of subjective tinnitus:

Sudden hearing loss

Acute noise trauma

Acoustic trauma deafness (caused by constant noise pollution)

Idiopathic labyrinthine deafness

Labyrinthine deafness caused by an autoimmune disease

Presbyacusia

Ménièr’s disease (ad hoc upcoming over-pressure in the inner ear)

Otosclerosis

Chronic otitis media

Craniocerebral trauma with or without fracture of the petrosus bone

Acoustic neuroma (tumour of the acoustic nerve)

Intoxication with quinine, acetylsalicylic acid (Aspirin), diuretics, amino glycoside antibiotics, Cisplatin, chemotherapeutics

Cardiovascular disease: cardiac dysrhythmia, high blood pressure

Metabolic disorder (most of all diabetes mellitus)

Kidney disease

Polycythaemia

Anaemia

Disorder of the central nervous system (tinnitus frequently with multiple sclerosis)

Degenerative changes and functional disorders of the cervical spine

Functional disorders of the jaw joint

Muscular causes

Functional disorders of tubes

2.4.2 Objective tinnitus

There is a physical sound source within the body close to the ears where the sound emissions are audible. Vascular, muscular, haematological, inflammatory or respiratory processes are the cause of these sounds. Objective sounds can also be heard by the examiner or registered with technical appliances. Objective sounds are uncommon, but in most cases there is a serious clinical picture in the foreground. (Feldmann, 1998, p. 37)

Vegetative functions, such as breathing, digestion and blood circulation, cause vibrations and noises, which under normal circumstances are hardly registered or accepted to be normal. If all of them were audible, they would cover outer sound signals of medium and high frequencies. (Feldmann, 1998, p. 38)

Possible causes of objective tinnitus:

Vascular causes:

Extracranial localisation:	Stenosis of carotid artery
	Stenosis of vertebral artery
	Glomus carotid tumour
	Haemangioma (cervical)
	Jugular outlet syndrome
	Heart vitium
Intracranial localisation:	Arteriovenous fistula

	Haemangioma (intracranial)
	Arteriosclerosis of cerebral arteries
	Glomus tympanic tumour
	Glomus jugular tumour
	Raised bulb of jugular vein
Muscular causes:	
Middle ear muscles:	Spasm of tensoris tympanic muscle
	Spasm of staped muscle
Palatal muscles:	Palatomyoclonus of tensoris veli palatini muscle
	Palatomyoclonus of levator veli palatini muscle
Altered rheology:	Anaemia
	Polycythaemia
Inflammations:	Acute otitis media
	Chronic otitis media
Functional disorder of tubes:	Gaping or open tube
Spontaneous otoacustical emissions	

(Feldmann, 1998, p. 86)

Vascular alterations and stenosis of carotid artery and vertebral artery, but also heart defects, can cause blood flow murmur which becomes transferred to the ears. Normally the pulse is not audible, because the inner ear, which converts the sound waves to nerve impulses, is free of blood vessels. The essential nutrients are located in the endo- and perilymph, which constantly flushes this area. (Biesinger, 2005, p. 53)

Pathological alterations of the arteries typically cause a tapping or murmuring that is synchronous to the pulse beat, which normally is sensed only in acceleration of the heart rate or in increased blood pressure. In most cases, the examiner hears the blood flow murmur in the surrounding of the ears by use of a stethoscope. (Biesinger, 2005, p. 53-54)

Irrespective of this, pulsating tinnitus has to be thoroughly diagnosed prior to symptomatic treatment. (Feldmann, 1998, p. 38) In most cases of pulse synchronous tinnitus, surgery is necessary due to an artery disease. (Biesinger, 2005, p. 54)

Constant flowing noises can be caused by venous draining disturbances, such as the jugular outlet syndrome (occasionally pulse synchronous) or by increased perfusion of vessels, such as anaemia. (Feldmann, 1998, p. 88)

Muscular dysfunctions such as malocclusion of dentition and resulting strains of the jaw joints or a pathological tone of the mastication muscles at the bruxism can primarily cause clicking ear noises. These may also be audible during the opening motion of the Eustachian tube, when the coordinated action of both palatine muscles, tensoris veli palatini muscle and levator veli palatini muscle, is disturbed. (Feldmann, 1998, p. 39)

Furthermore, a myoclonus of muscle in the palate, tube and middle ear may cause clonic convulsions at the velum palatinum. These short convulsions supposedly incorporate the M. tensor tympani (innervation: third ramus of trigeminal nerve), whose tendon is directly attached to the malleus where it can directly pick at the tympanic membrane. Likewise possible is a myoclonus of the staped muscle (innervation: facial nerve), whose tendon is attached to the head of the stapedius bone, which becomes tilted over its own lateral axis. This motion is transferred by the other stapedius bones to the tympanic membrane. The reason for these convulsions is unknown, but it is assumed that there is an analogy to the facialistic and the trigeminal neuralgia (tic douloureux). The facial nerve and trigeminal nerve may be stimulated by contact with a pulsating artery in the brain and react to it with lightning-fast innervation impulses. (Feldmann, 1998, p. 39-40)

Breathing-dependent ear noises can be found in the gaping tube. (Feldmann, 1998, p. 88) Because of the disturbed function of the closing mechanism a murmur or annoying ambient noise can be caused during swallowing or chewing. (Biesinger, 2005, p. 55)

2.5 Epidemiological data

The increasing presence of tinnitus among the population and the resulting advancing pertinence for ENT medicine seems to be linked to the rapid industrial and technical, and also social development of the last 50 years. (Schaaf et al., 2004)

At the German ENT Congress 2003 on the subject of “Integrated Sustenance with Tinnitus” (Maier et al., 2003) it was determined that tinnitus is more common than previously assumed.

The occurrence of ear noises peaks between the age of 50 and 70 years.

35% - 45%	(32 million) of all adults in Germany sense ear noise(s) from time to time
26%	(18.7 million) Germans had one bout of tinnitus
13%	(9.8 million) had ear noises > 5 minutes

Tinnitus patients in Germany with a need of therapy:

4%		(2.9 million) currently have tinnitus
Thereof	91%	(2.7 million) suffer from chronic tinnitus
	50%	(1.5 million) have grade III and IV tinnitus

Maximum suffering tinnitus patients

0.5%	(approx. 600,000) of all German citizens are affected by such severe tinnitus that they are unfit for work and receive constant medical care.

Every year, the number of tinnitus patients throughout Germany rises by approx. 270,000, with a remarkably increasing tendency.
In addition, 44% of the patients suffer from hyperacusis besides chronic tinnitus.

Effective and thorough medical care for these patients has not yet taken place. After completion of the repair process in the inner ear after three months, no useful further treatment with medication is possible. However, treatment is carried out frequently, in order to “offer something at least”.

At the congress it was clearly stated that uncoordinated individual measures are not promising. A proposition of outpatient treatment of tinnitus, initially for the Ulm area, was introduced. Thanks to the specific cooperation of a team of physicians representing ENT, neurology, psychiatry, where necessary also orthopaedics, dental and maxillofacial surgery with hearing aid technicians (hearing aid, masker therapy), behaviour therapists, relaxation therapists, physiotherapy and also osteopathy, the concept introduced at the Tinnitus Therapy Centre in Ulm has been successful.

A clear reduction in the suffering has been observed. In all therapy groups (age, degree of severity) significant stabilisation has been achieved. The achievement was more distinct in less serious cases than in more severe ones, and more distinct with shorter than with longer anamnesis. A significant goal by holistic efforts is to lead the patient from decompensated tinnitus back to compensated tinnitus. (Maier et al., 2003)

2.6 Problems and difficulties in recording tinnitus

To this day there are still difficulties in recording objective measurements of subjective tinnitus. Currently, there are two methods used in an attempt to record audible perception.

The measurement of the intensity of tinnitus is carried out by a psycho-acoustical comparison measurement. The noise perception of tinnitus in dB (hearing level or sensation level) is determined by comparing to a defined acoustic signal from an audiometer. (Goebel, 2001, p. 326)

The loudness of tinnitus is measured psychometrically using an analogue scale or a verbal scale. (Goebel, 2001, p. 326) Unlike the intensity of tinnitus, it is a subjective impression of tinnitus strength.

When measuring the intensity of tinnitus the goal is to objectify the subjective feeling the patient has. However, this value is indeed based on the "subjective feeling" of a patient. After careful considerations it can be clearly stated, that the subjective perception of a patient is the reason for consulting a physician. Tinnitus is a subjective perception, actually a misinterpretation, which disturbs the normal course of life. This subjective feeling is the real benchmark of a patient, crucial not only for the illness pattern but also for its improvement. Therefore this measurement is important. (Dräger, 2000, p. 4-5)

Due to the complexity of the "tinnitus illness pattern" more difficulties with the standardised recording are encountered. Since tinnitus can exist in one or more frequency ranges, with varying loudness and diverse sound quality and localisation, it is difficult to compile a classification in a defined schedule. For example, a patient may hear multiple sounds at a certain time. Most of the time the patient notes a leading sound which can also vary in loudness. Additionally, the development over time can bring gradual or erratic changes. Furthermore, tinnitus can be influenced by most patients. Most of the time it is a negative change, however, where the loudness of tinnitus increases, e.g. by tilting or turning the head, by clenching the teeth or through too much work and stress. (Dräger, 2000, p. 5)

3. Anatomy and physiology of the auditory system

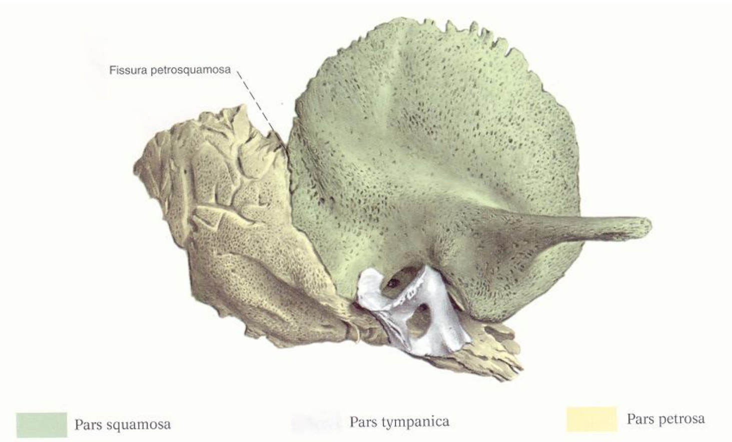
Still (1992), the founder of osteopathy, describes the anatomy as an absolute basic requirement for osteopathy. (Still, 1992, p. 7) Therefore, referring to tinnitus I would like to examine in detail the os temporale as "the home of our hearing organ" to present the complex and numerous connections to other body systems. On the one hand the temporal bone is the "mediator" between external sound reception and internal processing. On the other hand it is responsible for the balance between external fascial and internal membranous tensions. The following anatomic principles are based on Liem (1998).

3.1. Os temporale

The temporal bones are situated laterally in the middle stage of the cranium. They are part of the subcrania and calvaria and form an interface between the posterior and anterior part of the cranium.

3.1.1 Osteogenesis

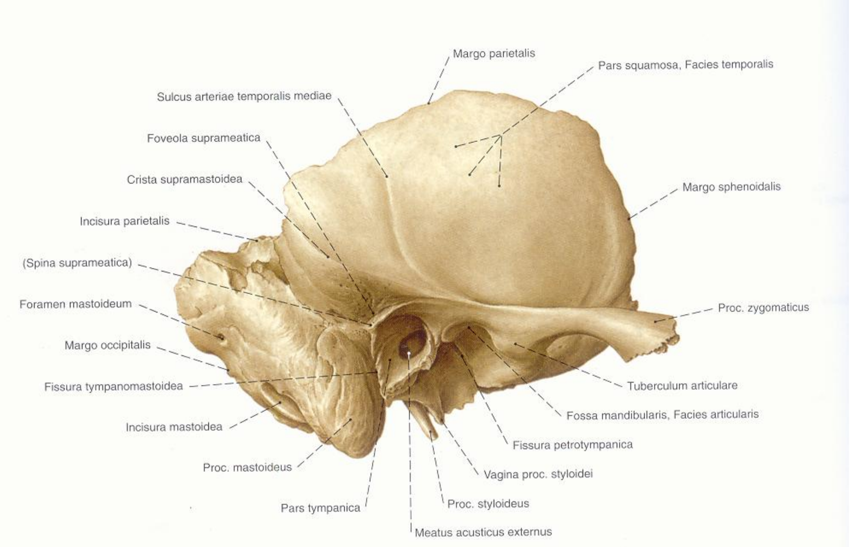
The os temporale emerges from three parts: pars squamosa, pars mastoideus and pars petrosa with pars tympanica, which have different embryological origins.



Ill. 1 Os temporale of a newborn baby (Putz, 1993, p. 60)

At the time of birth the pars squamosa, pars petrosa and pars tympanica, which correspond to the external auditory canal, are partly merged with each other. The fissura petrosquamosa, which results from this, can form a potential area for an intraosseous lesion. (Liem, 1998, p. 96) The mastoid process and styloid process, which has an embryological connection to the hyoid bone (stirrup, temporal styloid process and little horn of hyoid bone emerge from the second branchial arch), are not ossified. It is not until the age of one that the mastoid process develops as the body straightens. The pars squamosa and pars tympanica are of membranous origin, the pars petrosa is of cartilaginous disposition. In embryological terms the mastoid emerges from two bones: pars squamosa and pars petrosa. Because of the fusion of these parts fissures result, which are theoretically immobile, but from an osteopathic point of view, they have certain flexibility. (Arlot, 1997)

3.1.2 Pars squamosa



Ill. 2 Os temporale from lateral side (Putz, 1993, p. 60)

The plane semicircular squama forms a part of the lateral cranium, the roof of the external auditory canal and the mandibular fossa of the jaw joint. (Liem, 1998, p. 90)

Temporal facies:
Through the arch of zygoma the lateral surface of the squama is divided into a superior plane convex part for the major insertion of the temporal muscle, which is covered with the temporal fascia, and into an inferior horizontal area, which contacts the spina ossis sphenoidalis of ala major and pars petrosa. This inferior area covers the horizontal radix of the zygomatic process with the mandibular fossa. The joint capsule for the jaw joint is attached to the articular process. (Liem, 1998, p. 90-91)

The axis of mandibular fossa goes from superior anterior lateral to inferior posterior medial. Dorsomedial of this fossa are the petrotympanic fissure (fissure of Glaser), where the tympanic chord passes through. The tympanosquamosa fissure provides the contact between the dorsal wall of osseous auditory canal and the squama. (Liem, 1998, p. 91)

The sphenosquamosa suture connects the anterior inferior margin of squama with the squamosa margin of ala major. The parietosquamosa suture forms the cranial articulation with the parietal bone. (Liem, 1998, p. 158)

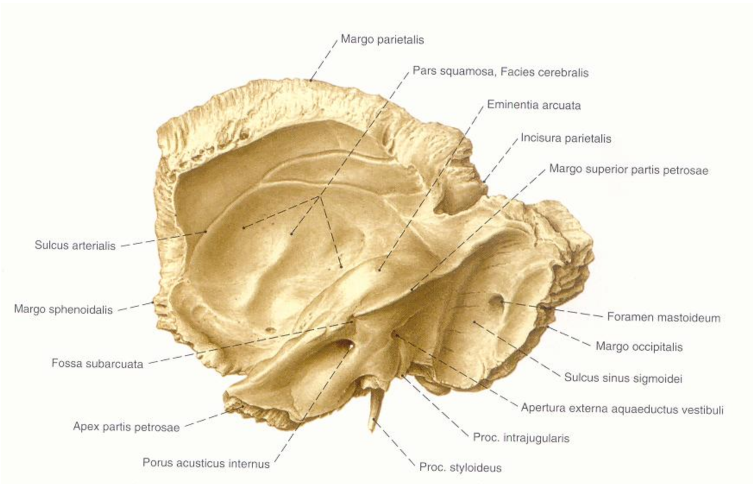
Processus zygomaticus:

First the zygomatic process, which stems from the squama, continues horizontally in an anterior and lateral direction, where it is hollowed for the posterior part of temporal muscle. The temporal fascia and the masseterica fascia are brought into contact at this hollow. Posterior the horizontal part forms the supramastoidea crista above the hearing canal and passes into the temporal linea. In the anterior direction the zygomaticus process oblates from medial to lateral. The inside surface of the zygomatic process is even and concave. The temporal fascia (aponeurosis) inserts at the superior margin, the strong masseterica muscle inserts at the big interior margin. (Liem, 1998, p. 91)

The mandibular fossa, which represents an anterior chondral socket for the mandibular caput, is situated under and between both radices of the zygomatic process on squama, between articulare tuberculum and external acoustic meatus. Between the jaw joint and mastoid process lies the parotid gland. (Arlot, 1997)

Anterior the zygomatic process connects with the zygoma bone (temporozygomatica suture). This creates a direct crossover to the viscerocranium. (Liem, 1998, p. 91)

Cerebral facies:



Ill. 3 Os temporale from medial side (Putz, 1993, p. 61)

The slightly concave medial side represents the temporal fossa (cerebral fossa), formed by pars squamosa and pars petrosa, protects the temporal lobe of cerebrum hemisphere. The cerebellum lies at the back of the pars petrosa. (Arlot, 1997)

Inside there are impressions, the cerebral juga, digitatae impressions and a deep arteriosus sulcus for the branch of the medial meningea artery. Especially the sphenosquamosa suture can be a sensitive area for the medial meningea artery. The petrosquamosa fissure is inferior. (Liem, 1998, p. 91)

3.1.3 Pars mastoidea

The anterior third of mastoid is formed by the pars squamosa (membranous), the posterior two-thirds is formed by the pars petrosa (cartilaginous). It is situated in the inferior posterior area behind the pars tympanica. The mastoid process goes into an inferior anterior, slightly medial direction. (Liem, 1998, p. 91-92)

The pars mastoidea is divided from the pars tympanica by the tympanomastoidea fissure, where the auricular ramus of vagus nerve goes through. The auricular cartilage adheres at the suprameatica spine, where there are many apertures for vessels. Inside the mastoid process there are cavities, the mastoid cellulae, which are pneumatised from the tympanum. (Liem, 1998, p. 92)

The strong muscle insertions on the mastoid are very relevant in osteopathic treatment. The forceful sternocleidomastoideus muscle and splenius capitis muscle insert at the posterior inferior raw area. The digastricus muscle, the levator of hyoid bone, inserts medial inferior posterior at the mastoid incisura. (Liem, 1998, p. 92)

Liem (1998) writes: “Statomotoric influences particularly from the pelvis can transmit to the pars mastoidea because of the muscle insertions. An indication of this connection is the relatively isochronic generation of mastoid process with the child’s straightening. (Liem, 1998, p. 91)

Furthermore these strong muscle insertions affect the occipitomastoidea suture and parietomastoidea suture. Often a suturale compression in this area reflects hypertonic muscles. (Liem, 1998, p. 157)

Endocranial the mastoid is involved in the formation of the posterior cranium. Under the insertion of tentorium cerebelli the fossa cerebelli is found, which is formed by the inside mastoid and posterior part of pars petrosa. (Liem, 1998, p. 91)

The wide sulcus for sigmoid sinus is very conspicuous at the inside area of mastoid. The mastoid foramen in the sulcus of sigmoid sinus represents the aperture for emissaria vein. (Liem, 1998, p. 91) Three different venous systems meet in the canal of emissaria vein: sigmoid sinus (lateral sinus) of the internal jugular vein, posterior jugular vein and vertebral veins. It acts as a safety valve. (Arlot, 1998)

3.1.4 Pars petrosa

The pars petrosa is a four-sided pyramid. The basis is posterior and the apex is anterior medial between sphenoidale bone and occipital bone. Therefore the petrobasilar synchondrosis is a part of the subcrania. (Liem, 1998, p. 93)

The jugular facies of pars petrosa forms the face of articulation to the jugular facies of the occipital bone. From an osteopathic point of view the petrojugular synchondrosis is an important area, as here the temporal bone "sits" on the occipital bone. Next to it there is the jugular fossa, which forms the aperture for the internal jugular vein. Around 95% of venous blood is discharged through the jugular foramen via the jugular vein. Additionally cranial nerves (glossopharyngeal nerve, vagus nerve, accessorial nerve) leave the cranium through the jugular foramen. (Arlot, 1997)

Anterior facies:

The anterior facies points in an anterior superior lateral direction and is part of the middle cranium, where the temporal lobe is situated. The small depressions, the fovealoae granulares, are formed by the arachnoideales granulations. The trigeminal ganglion forms the trigeminal impression at the apex of the pars petrosa. (Liem, 1998, p. 93)

Inwards there is only a small osseous lamella, which divides the pars petrosa from carotic canal. This canal proceeds at the top and crosses the apex of the pars petrosa. (Arlot, 1997)

The arcuata eminence is an elevation as a result of the anterior semicircular canal. To the side of it a thin osseous panel forms the roof of the tympanic tegmen. (Liem, 1998, p. 93)

The petrosquamosa fissure forms the roof of the tympanic cavity. Parasympathetic parts of the tympanic chord and sympathetic parts of the caroticotympanic nerve, which is accountable for the mucosa between the air cells of mastoid process and Eustachian tube, are present here. The petrosquamosa fissure often persists for life, making an osteopathic release of this intraosseous dysfunction of relevance. (Plothe, 2006, p. 27)

Anterior there are two apertures: through the hiatus for the canal of the major petrosus nerve to the lacerum foramen runs the major petrosus nerve (ramus of facial nerve), which brings secretoric fibres to the pterygopalatine ganglion, and a ramus of medial meningea artery. Lateral there is the hiatus for the canal of minor petrosus nerve, which goes to the oval foramen, and the superior tympanic ramus of medial meningea artery. (Liem, 1998, p. 93)

The sphenopetrosa facies is linked to the posterior margin of the sphenoidale ala major as a formation for anterior and posterior margin of lacerum foramen. The sphenopetrosa suture is the connection of the apex of pars petrosa with the dorsum sellae (rear wall of hypo physical cavity) by the sphenopetrosa ligament (ligament of Grüber) of tentorium cerebelli. (Liem, 1998, p. 157) The ocular muscle nerves (oculomotoric nerve, trochlear nerve and abducens nerve) run near this ligament alongside the corpus of sphenoidal bone. If there is hypertension in the ligament of Grüber, the abducens nerve in particular is very susceptible to increased irritation, which is often caused by tooth extraction at the homolateral maxilla bone. (Liem, 2003, p. 86)

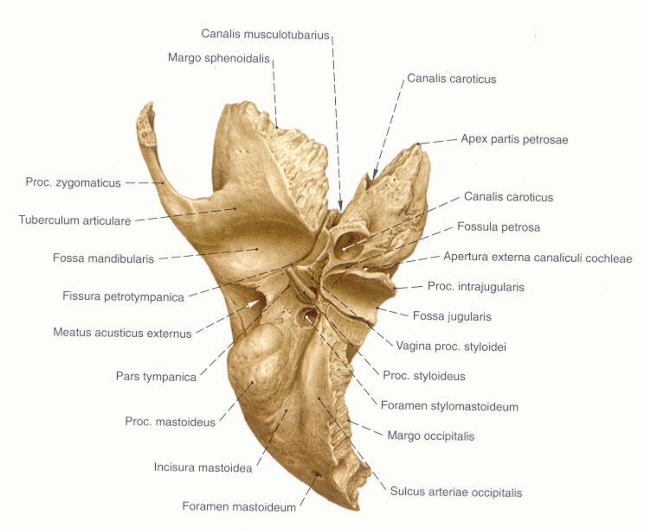
Facies posterior:
The posterior facies forms the anterior wall of the posterior cranium. A part of the cerebellum leans against this wall. The tentorium cerebelli, which is the membranous continuum to the falx cerebri, falx cerebelli and spinal dura mater, inserts at the superior margin of the pars petrosa. (Liem, 1998, p. 93)

At the superior margin the superior petrosus sinus proceeds in the sulcus. The inferior medial margin forms with the basilar pars of occipital bone a sulcus for the inferior petrosus sinus. (Liem, 1998, p. 93-94)

In the posterior wall of the pars petrosa there lies the aperture for the internal auditory canal, where the facial nerve, intermedius nerve (ramus of facial nerve), vestibulocochlear nerve, labyrinth arteries and labyrinth veins (venous branches to the inferior petrosus sinus) pass through. Parasympathetic fibres partly accompany the facial nerve and innervate the eardrum. Because of this, hearing can be affected by vegetative disorders. (Liem, 1998, p. 94)

The endolymphatic duct is found in the external aperture of the vestibular aqueduct behind the internal acoustic porus. Here the dura mater comes into contact with the duct. Below there is the cochlear canaliculus for the perilymphatic duct. This thin canal is the facility of the perilymphatic space to the subarachnoidal space. (Liem, 1998, p. 94-95)

Inferior facies:



Ill. 4 Os temporale from caudal (Putz, 1993, p. 61)

At the three-sided caudal area of the pars petrosa there are large canals for vessels and nerves and the aperture of the Eustachian tube.

The inferior part of the pars petrosa ends very close to the basilar process of the occiput and forms the lateral wall of the pharyngeal region. The pharynx inserts at the foramen lacerum and at the inferior area of pars petrosa until the foramen caroticus. (Liem, 1998, p. 98)

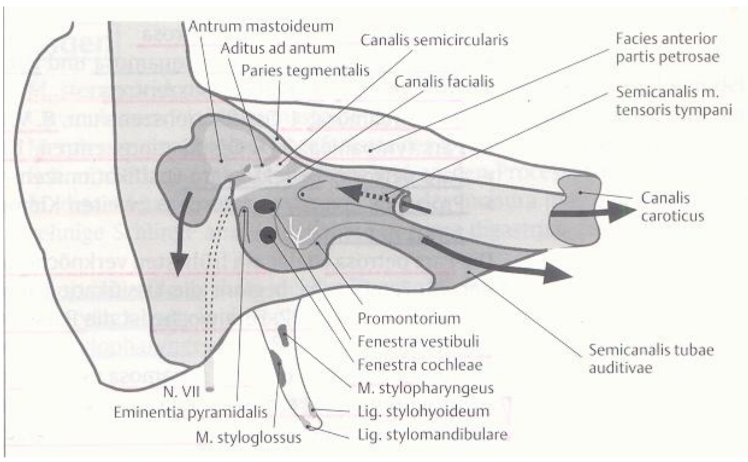
The styloid process extends in an anterior inferior direction and acts as an insertion area for the stylohyoid muscle, styloglossus muscle and stylopharyngeal muscle. Furthermore there is an insertion of the stylomandibular ligament and the stylohyoid ligament. This connection is responsible for the hyoid bone having a regulative influence in the case of tension at the tentorium cerebelli. (Liem, 1998, p. 380)

The stylomastoid foramen is formed by the styloid process, mastoid process and jugular fossa. The facial canal, where the facial nerve and the stylomastoidea artery extract, exhibits a geniculum and goes from the internal acoustic porus to this foramen. The tympanic chord proceeds in the canaliculus of the tympanic chord between the facial canal and the tympanum. (Liem, 1998, p. 94)

The mastoid canaliculus proceeds from the jugular fossa through the facial canal to the tympanomastoid fissure. The auricular ramus of the vagus nerve goes through this canaliculus. (Liem, 1998, p. 94)
The tympanic nerve and the tympanic artery run in the fossula petrosa, an impression between the jugular fossa and carotic canal. (Liem, 1998, p. 94)

The carotic canal, which leads the way for the internal carotid artery and a network of sympathetic nerves, runs from the inferior area of the pars petrosa to the lingula of the sphenoid bone. In the wall of the carotic canal there are fine apertures for arteries and nerve ramuses, which proceed to the middle ear. (Liem, 1998, p. 94-95)

Ahead of the carotic canal the pars petrosa is involved in the formation of the Eustachian tube. The musculotubar canal contains two canals: the superior canal is for the tensoris tympanic muscle and the inferior canal is for the auditory tube. The cartilaginous Eustachian tube inserts at the sulcus of auditory tube. (Arlot, 1997)



Ill. 5 Pars petrosa with tympanum from inside (Liem, 1998, p. 95)

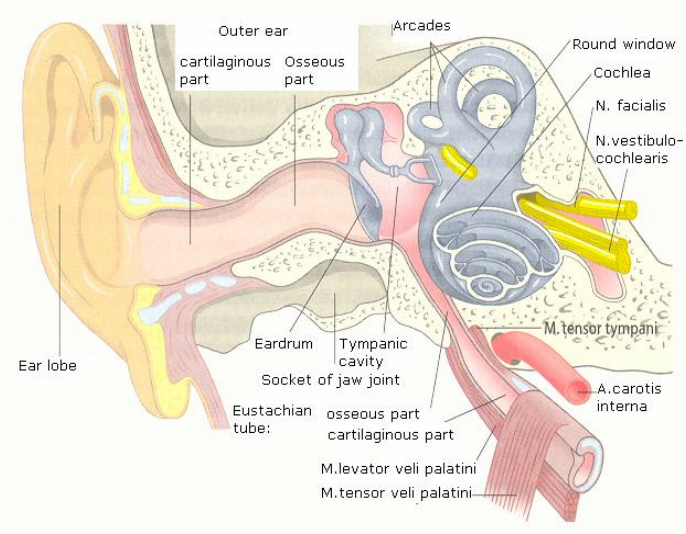
3.1.5 Pars tympanica

The pars tympanica is the osseous aperture of the auditory canal. The eardrum, which separates the external auditory canal from the tympanum, inserts at the tympanic sulcus. The anterior area of pars tympanica forms the posterior non-articular part of the mandibular fossa along to the petrotympanic fissure. The vagina of styloid process abuts to the radix of styloid process. (Liem, 1998, p. 95)

Cavum tympani:

The air-filled tympanum between the osseous labyrinth and the eardrum is the central part of the middle ear. Posterior superior it is in contact with the air-filled mastoid cellulae of the mastoid antrum. Furthermore there is a connection to the nasopharyngeal space by the approx. four centimetre long cartilaginous-osseous auditory tube. Anterior the tube is regulated by the tensoris veli palatini muscle and levator veli palatini muscle. (Liem, 1998, p. 95-96)

3.2. Outer ear



Ill. 6 Overview of the ear (Boenninghaus/Lenarz, 2005, p. 6)

The outer ear consists of both the flexible, cartilaginous ear lobe that receives sound waves, and the outer auditory canal (external auditory meatus), that is separated from the middle ear by the eardrum. The conchal cavity merges into the outer auditory canal. This 3 to 3.5 cm long canal has a narrow bend (isthmus) where the cartilaginous part merges into the osseous part of the auditory canal. The osseous wall is to be found with the mastoid antrum behind, in the upper part of the canal. The facial nerve runs through the lower back area of the auditory wall. The front wall of the outer auditory canal borders on the jaw joint and the parotid gland. The upper wall is connected to the epitympanum and the temporal muscle. (Boenninghaus/Lenarz, 2005, p. 6-7)

The sound waves, providing they supply an adequate stimulus for the peripheral auditory system, are seen as a result of air pressure variations, the amplitude of which is measured in decibels (dB). The frequency of the sound is measured in hertz (Hz) as vibrations per minute which define the pitch. The human physiological hearing range (audibility limit) ranges from 16 Hz to 20,000 Hz. (Rütz, 2006, p. 9)

Sound waves are already intensified with frequencies between 2,000 to 4,000 Hz through a resonance effect in the outer auditory canal. The force of resonance increases in the middle ear through the lever system of the auditory ossicles bones (malleus, anvil and stirrup). An even stronger frequency is created through the comparative difference in surface area between the eardrum and stirrup. In this way the outer and middle ear are responsible for the manner in which specific frequencies are experienced. (Hellbrück/Ellermeier, 2004, p. 98-99)

The outer ear is not a vital organ, however it does represent a sense of life and honour. One only has to think of the “War of Jenkins’ Ear” in 1739 that broke out through an ear being cut off. In the New Testament (Matthew 26:51) it is recorded that a companion of Jesus cut off an ear of the high priest’s servant in the garden of Gethsemane. The painter van Gogh cut off his own ear. It is interesting to consider how many kidnapped people have had their ears cut off as a sign of their captor’s power over body and life. (Ackermann, 2003, p. 44)

In traditional Chinese Medicine face diagnosis, large and well formed ears and ear lobes are a sign of wisdom, a strong constitution and a long and happy life. Ears open the way to the kidney meridian. (Ploberger, 2005)

3.3. Middle ear

The middle ear commences with the eardrum and includes the Eustachian tube, tympanic cavity and pneumatic spaces. The eardrum (tympanic membrane) resembles a narrow funnel with a bend, and separates the external auditory canal from the tympanic cavity. (Boenninghaus/Lenarz, 2005, p. 7)

The eardrum not only provides protection for the middle ear but also acts as an acoustic receptor in that it is set into motion by sound. In this way, sound is transmitted to the ossicles. (Rütz, 2006, p. 10) The middle ear is connected by the Eustachian tube to the pharyngeal cavity in order to maintain the same atmospheric pressure as the outside world. (Hellbrück/Ellermeier, 2004, p. 92)

The Eustachian tube is approximately 3.5 cm long. The last third, found in the pars petrosus of the temporal bone, is bony and lies in the osseous Eustachian canal under the semicanal of the tensoris tympani muscle. The frontal two thirds, which go in a pharyngeal direction, make up the cartilaginous membranous part that is attached to the skull basis, the synchondrosis sphenopetrosa. (Rütz, 2006, p. 11) The tube cavity consists of a fissure in the osseous area so that the walls lie against one another. Pressure is evened out primarily by swallowing whereby the tensoris veli palatini muscle and the levator veli palatini muscle are opened through the shifting of the groove-like cartilaginous tube and the lifting of the velum. (Boenninghaus/Lenarz, 2005, p. 11)

The isthmus is of osteopathic significance. The narrowest part of the tube between the cartilaginous and osseous part is often dysfunctional. The internal carotid artery runs medially of the tube. The extension of the pharyngobasilaric fascia to the inferior wall of the cartilaginous membrane allows a connection to the pharynx. Consequently an exchange of air through the tuba auditiva between the tympanic cavity and nose/throat area is possible. Therefore the air pressure can remain the same on both sides of the eardrum, which serves to pass on sound waves optimally. Apart from this, the cleaning of the middle ear is ensured through secretion. (Rütz, 2006, p. 11)

The three bones of the ossicles are to be found in the tympanic cavity: the hammer (malleus), the anvil (incus) and the stirrup (stapes). The chain effect of the ossicles allows vibrations to be transferred from the eardrum to the perilymph in the inner ear. The mallet finger and the short extension of the hammer are built into the tensions part of the eardrum. The frontal extension is directed towards the fissure of Glaser. The hammer is connected to the anvil via a saddle joint. Furthermore, the long anvil leg reaches down and is connected to the stirrup head in its lenticulating process through a sliding joint. The stirrup is divided into a frontal and posterior part. The footplate connects to the oval window, the purpose of which is to build a barrier to the inner ear. The vibrations of the eardrum are transmitted through the oval window to the perilymph of the inner ear. (Boenninghaus/Lenarz, 2005, p. 12)

The process of the conduction of sound waves from the larger area of the eardrum to the smaller of that of the oval window results in a concentration of sound which causes a rise in pressure. The tympanic cavity forms a sound bridge, whereby the low sound wave resistance (acoustical impedance) of the air can be evened out against the high sound wave resistance of the fluid-filled inner ear. (Boenninghaus/Lenarz, 2005, p. 12)

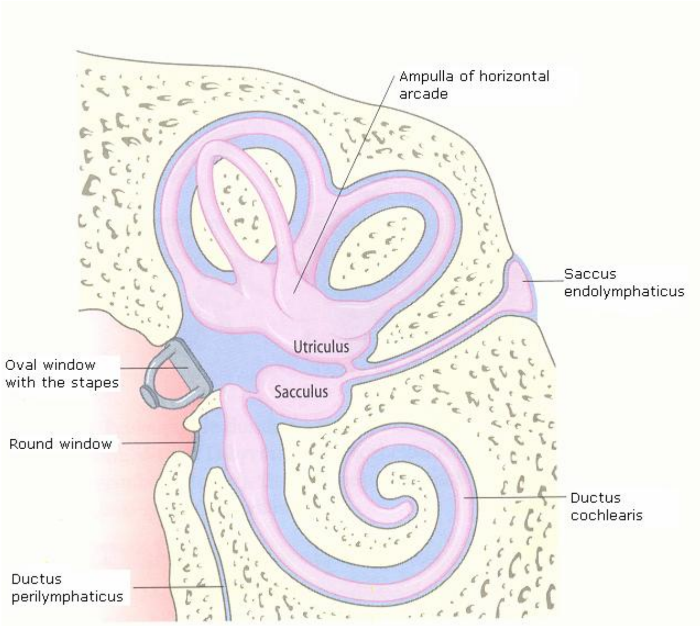
The smallest muscles in the human body are to be found attached to the ossicles and they function synergistically. The tensoris tympani muscle (innervation: third ramus of trigeminal nerve) that emerges from the semicanal of the tensoris tympani muscle, finds its origin in the osseous part of the bordering region of the sphenoidal ala major and is attached to the mallet finger. It serves as a tensioner for the eardrum. (Hellbrück/Ellermeier, 2004, p. 92) The staped muscle (innervation: facial nerve) leaves the pyramidal process and connects on the head of the stirrup. If the sound level becomes too high the stirrup is pulled down. This precaution prevents the transmission of excessively loud noise to the inner ear. (Biesinger, 2002, p. 55) On the other hand the relaxing of the muscles heightens the sensitivity to acoustically weaker sound. Conductive modulation is important for understanding speech in loud background noise. It is assumed that partial paralysis of these muscles occurs in the case of hyperacusis, which often accompanies tinnitus. (Rütz, 2006, p. 11)

There is a close proximity to nerves and veins due to the confinement of the area: the hypotympanum lies separated by a thin osseous wall immediately above the bulb of the superior jugular vein. The front wall of the mesotympanum is in the neighbourhood of the carotic canal. The facial nerve runs through the back of the osseous wall of the mastoid process. The tympanic chord emerges from under the stirrup (from the fibrous tissue of the intermedius nerve, the non-motoric part of the facial nerve). It forms an arc between the mallet finger and the thigh of the anvil through the tympanic cavity. There it leaves through the fissure of Glaser. The tympanic nerve, a parasympathetic ramus from the glossopharyngeal nerve, runs along the promontory of the medial wall that is formed from the basal convolution of the cochlea; it is made up of sensitive fibrous tissue that also forms the mucus membrane of the tympanic cavity. (Boenninghaus/Lenarz, 2005, p. 12-15)

The tympanic cavity is connected below and at the back of the tympanic scale of the cochlea through the round window. The boundary is formed by the “second eardrum”, the second tympanic membrane. The function of the round window lies in the transmission of the sound waves that have already been received by the sense cells of the inner ear. In this way it provides pressure compensation for the inner ear that is necessary because of the fact that fluids are non-compressible. (Rütz, 2006, p. 10)

The epitympanum has its opening in the mastoid antrum, the access to the mastoid air cells which provide ventilation. Behind the bulge of facial nerve the horizontal osseous arcade lies on the medial wall of the mastoid antrum. The roof of tympanic tegmen borders on the middle cranium. (Boenninghaus/Lenarz, 2005, p. 12-13)

3.4. Inner ear



Ill. 7 Endo- and perilymphatic spaces (Boenninghaus/Lenarz, 2005, p. 16)

3.4.1 Peri- and endolymphatic spaces

The anatomy of the inner ear shows a close relationship between the structure of the cochlea and the cerebrospinal fluid space. The osseous labyrinth in the petrosus part of temporal bone surrounds the membranous labyrinth like a protective cap. The perilymphatic space that is connected to the subarachnoidal space through the cochlear aqueduct is found between the bone and the membranous labyrinth. According to biochemical investigations the perilymph stems partly from cerebrospinal fluid but is also filtered from the blood. The perilymph is connected to the perilymphatic space of the tympanic scale and washes around the sense cells of the organ of Corti. (Boenninghaus/Lenarz, 2005, p. 15)

The membranous labyrinth is filled with endolymph. This originates in the stria vascularis and is reabsorbed in the endolymphatic sac. (Boenninghaus/Lenarz, 2005, p. 15) The endolymphatic sac is found subdurally at the rear of the pars petrosa. It is a flat, bubble-like space which reminds one of a reservoir. The endolymphatic duct and sac assist pressure balance in the membranous labyrinth. It is, however, exposed to the pressure of liquor. (Dräger, 2006, p. 18)

Whereas the perilymph is rich in natrium and contains little kalium, the endolymph is rich in kalium and has little natrium. The differences in these electrolytic concentrations are maintained by active ion transport and passive diffusion. (Dräger, 2006, p. 18)

Frick et al. (1987) describe that the awareness of sound is generated by pressure waves that are transferred through the perilymphatic space onto the endolymphatic space. It appears, according to Rohen (1985) that functional pressure balance is decisive for the healthy functioning of the organ of Corti as well as the metabolism of the individual cells. He argues that the dysfunction of the ion milieu of the endolymph can lead to a malfunction of the sensory epithelium. Furthermore it can lead to deafness from incorrect sound impressions. (Dräger, 2000, p. 5)

Benign intracranial hypertension is very common in cases of pulsatile tinnitus. As a result of this, one could come to the conclusion that the raised intracranial pressure of the endolymphatic sac reservoir hinders and lessens the possibility of compensation which could lead to tinnitus. (Dräger, 2000, p. 5)

3.4.2 Cochlea

The cochlea surrounds the actual auditory organs. The osseous cochlea spirals two and a half times around the modiolus which is an axis through which nerves and veins run. The two levels, filled with perilymph, are to be found in the modiolus, the vestibular scale and the tympanic scale. They are situated at the top of the cochlea and are connected to one another by the helicotrema. The membranous cochlea, the cochlear duct, is filled with endolymph. The cochlear duct is separated from the tympanic scale at the base by the basilar membrane that lies at the top of the organ of Corti. Here there are two tunnel-like forms filled with lymph of Corti and lined with sensory receptor hairs (an inner row and three outer rows). These hairs are embedded in the gelatinous otolith membrane, the surface of which contains tiny crystals of calcium carbonate (otolith). (Boenninghaus/Lenarz, 2005, p. 15-17)

The outer hair cells have muscular properties. A contraction has the effect of strengthening the approaching sound waves and thus influencing the otherwise weak, passive movement of the inner ear fluid. At the same time, over strong reactions of the basilar membrane are actively kept under control. This ensures that the inner hair cells that have no active ability of contraction are, through their optimal patheogenic position, able to be stimulated so that acoustic information can be transferred to the afferent system of the auditory system. (Goebel, 2001, p. 21)

Any injury of the auditory system can lead to tinnitus. Due to changeable, spontaneous activity and false input, subjective impressions can occur in the central auditory system. These impressions can become intensified through general learning processes and emotional associations. (Goebel, 2001, p. 17)

3.4.3 Arcades

The three semicircular arcades are situated horizontally, vertically and diagonally. The membranous arcades carry endolymph. They are found within the osseous arcade and are surrounded by perilymph. The passage of every arc in front of the entrance to the vestibule extends into an ampoule where the sensory cell hairs are to be found. (Boenninghaus/Lenarz, 2005, p. 18)

The vestibular organism is responsible for the sense of balance in coordination with the eye, the surface and deep sensitivity of the throat receptors as well as the conscious awareness of the head and body in conjunction with spatial orientation and balance. Spatial orientation is made possible through the various registrations of differing speeds, in particular of the rotation speed of the head. (Boenninghaus/Lenarz, 2005, p. 26)

Innervation of the inner ear:

The hearing and balance organ is supported by the vestibular-cochlear nerve (N. VIII). It enters the inner auditory canal together with the facial nerve (N. VII) and divides into the vestibular nerve and cochlear nerve. The vestibular ganglion lies at the basis of the auditory canal from where the utriculoampullar nerve, the saccular nerve and the posterior ampullar nerve support the arcades. The spiral cochlear ganglion is to be found within the modiolus and runs from the nerve network to the hair cells of the organ of Corti. (Boenninghaus/Lenarz, 2005, p. 18-19)

There is also proof that the cochlea is sympathetically supported, having its origin in the superior cervical ganglion. This could point towards the direct connection of tinnitus to the upper cervical spine and therefore justify osteopathic treatment. (Plothe, 2006, p. 28)

The vessels of the inner ear:

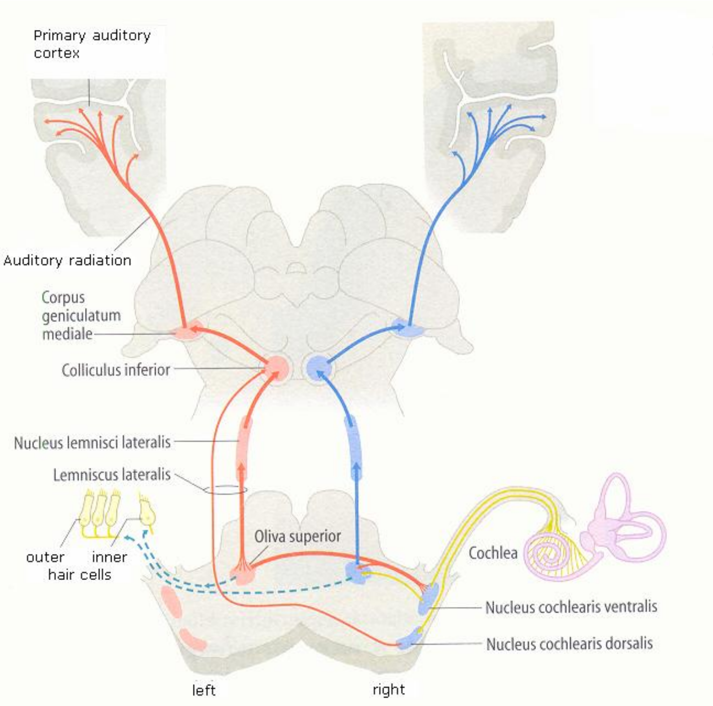
The labyrinth artery that supports the inner ear springs from the anterior inferior cerebellar artery or directly out of the basilar artery. It separates into the vestibular branch for the arcades and basilar modulus of cochlea and into the cochlear branch for the remaining basilar modulus of cochlea. A diminishing arterial supply to the cochlea is suspected particularly in the case of hearing loss. (Boenninghaus/Lenarz, 2005, p. 19) Most vessels in this area are not contractible. For this reason, cranial work on osseous and membranous structures could lead to relief in the vessels. (Plothe, 2006, p. 28)

The venous and lymphatic outlet could be of importance if one observes the emphasis that Rohen (1985) put on the ion milieus of the endolymph. The free flow of body fluids has the highest priority in osteopathic treatment.

3.5. Central part

3.5.1 Hearing tract

All structures of the central nervous system that are involved in the consciousness of hearing, from stimulation to sensory perception belong to the hearing tract. The connection to the speech centre is of essential importance. (Boenninghaus/Lenarz, 2005, p. 19) This way hearing is the mediator between speech as a social bond and the perception of the world. (Ackermann, 2003, p. 74)



Ill. 8 Hearing tract from dorsal, afferent tracts from the right cochlea, efferent tracts to the hair cells of left organ of Corti (Boenninghaus/Lenarz, 2005, p. 20)

The afferent hearing tract begins with the sensory hearing cells in the inner ear. The sound waves bring about distraction of the outer and inner hair cells where potential transformations are built up through the multiple-step ion processes in the hair cells. This leads to a breakdown of the transmitter quanta that lie at the basic end of the synaptic fissure. There the attached afferent auditory nerve tissue absorbs the chemically transmitted information. A suitable generator process is thus set up, whereby when a specific limit is exceeded by a particular sound wave, the action potential is activated and transmitted to the hearing system. (Goebel, 2001, p. 21)

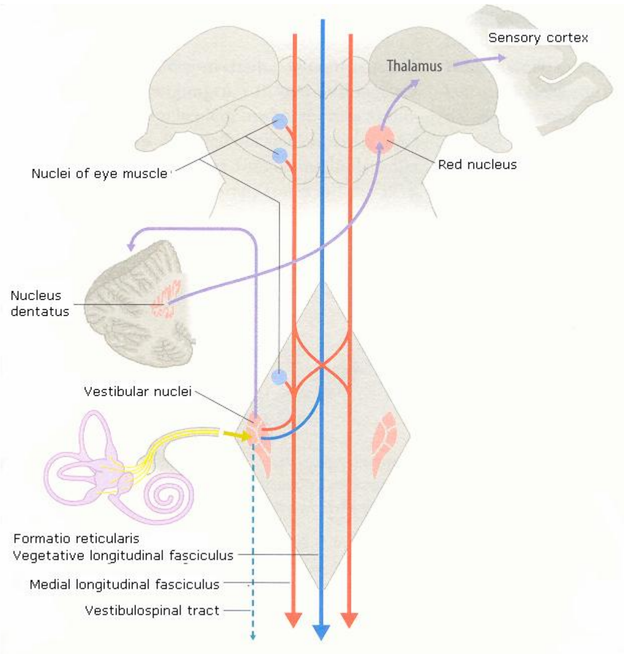
The largest part of the central afferent hearing tract intersects in the second neuron on the contralateral side. Tissue crosses from the dorsal cochlear nucleus to the inferior colliculus of the other side. More tissue crosses from the ventral cochlear nucleus mainly to the olive of the other side. A portion of the tissues runs without crossing to the same side. In this way every organ of Corti is connected on both sides to the auditory cortex. The cortical hearing spheres are connected together by the tissue of the corpus callosum. The third neuron runs from the olive superior via the inferior colliculus to the medial geniculatum corpus of the thalamus. The fourth neuron, the auditory radiation, runs from this point to the primary auditory cortex in the Heschl coil of the temporal lobe. (Boenninghaus/Lenarz, 2005, p. 20)

This is where the consciousness of auditory impulses takes place, albeit without any interpretation. Single tones of varying frequency are perceived, but no words or melodies. Auditory impulses that can be interpreted are perceived in the secondary auditory cortex and the surrounding projection fields where sounds are registered as words, melodies or noise. This process is dependent on the normal development of the auditory system where sounds are gathered and stored in this area, creating a memory bank of recognisable sounds. This area is also known as the sensory speech centre (Wernicke Centre). (Rütz, 2006, p. 14)

The efferent tracts that drive the sensory input run mainly from the contralateral olive and weave mostly across to the outer hair cells. A lesser amount runs parallel from the ipsilateral olive to the afferent auditory nerve tissue that leaves the inner hair cells. The peripheral hearing system is adjusted to every respective sound situation by the sensitivity regulation of the efferent tracts. (Boenninghaus/Lenarz, 2005, p. 20) The influences of the central hearing system, the limbic system as well as the autonomic nervous system are transmitted to the hearing sense cells through these tissues. (Goebel, 2001, p. 21)

3.5.2 Vestibular tracts

The vestibular tracts help to regulate balance. There is a specific constellation of shearing of the respective macular organs, the sacculus and utriculus of the right and left inner ear. There is also a specific state of sensitivity raised in the afferent nerve tissue that assists spatial orientation. (Rütz, 2006, p. 14) Together with the sight centre, the vestibular spinal centre, the cervical vertebrae, the cerebellum and the cortex, they form a multisensory system.



Ill. 9 Vestibular tracts (Boenninghaus/Lenarz, 2005, p. 21)

The vestibular nerve that extends from the sensory receptors to the three vestibular nuclei at the floor of rhomboid fossa represents the first neuron. In the second neuron a portion of the tissues travels across or parallel to the medial longitudinal fasciculus and the eye muscle centre, which explains the phenomenon of nystagmus. A further part leads to the reticular formatio and the vegetative centre. Another leads to the cerebellum and cerebelli cortex. In addition to this a vestibular tract leads to the frontal horn of the spinal cord and the motoric nerves that regulate the muscle tone. (Boenninghaus/Lenarz, p. 21)

Reflective, corrective movements can be rapidly yet unconsciously initiated via all these connections, providing body balance and stable vision. The information is transmitted via the cerebellum to the red nucleus of tegmental region. This information continues via the lateral nucleus of thalamus to the sensory cortex, the body sense sphere where spatial orientation becomes conscious. (Rütz, 2006, p. 15)

4. Osteopathic relevancy

4.1 Problems in current orthodox medicine

Diagnostics and therapy of noises in the ear are basically characterised by the absence of sound pathophysiological knowledge and the lack of tinnitus-specific methods of treatment. The huge number of patients who suffer from severe tinnitus shows that the situation is far from satisfactory. A multitude of therapeutic suggestions (cf. Biesinger, 2005, S. 168; Goebel, 2001, p. 99) with various, mostly hypothetical explanations has been presented and put into use in recent years. Here we can note a widespread therapeutic trend which lacks scientific support to a great extent. So, time and again individual authors report about an astonishing therapeutic success which, however, cannot be reproduced by other researchers. Therefore, both doctor and patient are confronted with a vast number of partly contradictory statements which make it impossible to take action in a planned and rational way. The patient might even suffer from additional iatrogenic damage because of the vast number of therapeutic methods whose effectiveness has not been proved yet. This makes his/her suffering even worse and might also prevent effective treatment. (cf. AWMF online)

One significant reason is the lack of standardisation of the applied diagnostic and therapeutic methods, including the parameters used for assessment and measurement. Only when the same criteria are applied coherently can the data of the treatments can be compared. These coherent standards are a condition for carrying out highly necessary, clinically supervised studies which examine the effectiveness of therapeutic methods both now and in the future. (cf. AWMF online)

When we consider the situation of the patients, they are often left to live with the noises in their ears. I will now explore whether osteopathy in collaboration with orthodox medicine might be a useful method of treatment to improve the quality of life of those concerned.

For this reason, only tinnitus patients who experienced no change to their situation after close medical examination and medicinal treatment were included in this study.

4.2 Tinnitus from an osteopathic point of view

From an osteopathic point of view we can start from the assumption that it comes to an ill-coding in the auditory area, especially in the case of subjective tinnitus, which is caused by a heightening of various bodily tensions coming from different origins which are passed on to the auditory system where they irritate/deceive its function of sensory perception.

The osteopathic work on tinnitus puts mainly the temporal bone – where the auditory system is located – in the foreground. Not only hearing, but also spatial orientation, straightening, balance and dynamic equilibrium is connected with the temporal bone. When we look at the numerous direct connections to different structures in the cranial area (see chapter 3) as well as the transmission via communication networks and lesion chains to the temporal bone, we can deduce a multitude of lesion possibilities.

The temporal is one of the most important bones of the cranium as it represents an intersection and a nerve centre; that is the reason why Sutherland called it the “origin of troubles”. When examining lesions, we will eventually have to come back to the temporal bone, even when the symptoms do not point to it at all. (Arlot, 1997)

On the other hand, however, the temporal bone “answers” dysfunctions and tensions of the locomotor system, the viscera, the internal carotid artery/internal jugular vein and the craniosacral system such as sutural or membranous dysfunctions, and very often also dysfunctions of the jaw joint. It does so by its manifold contacts with myofascial structures (sternocleidomastoid muscle, stylohyoid muscle, stylopharyngeal muscle, styloglossus muscle, venter posterius of digastricus muscle, levator veli palatini muscle, tensoris veli palatine muscle, stylomandibular ligament, stylohyoid ligament, etc.). (Arlot, 1997)

Liem (1998) argues that on account of the multiple possible causes, apart from structural dysfunctions, stress seems to be a frequent trigger of tinnitus, too. Also mental strain can lead to tinnitus via muscular fixations to the temporal bone. However, as long as the sensory cells in the vestibulocochlear organ are still intact, there remain good prospects of improvement or even disappearance of the symptoms. Otherwise, only the progress of the symptoms can be brought to a halt. The earlier the tinnitus is treated, the higher the chances of success. (Liem, 1998, p. 544)

4.3 Searching for causes/origins

When a system is put off balance, the new situation of the changed conditions is passed on by information systems and networks. It is exactly this point, seeing the human as a unit and considering the connections between the body systems and their dependency on each other, which corresponds with the osteopathic philosophy and which makes up the core of osteopathy.

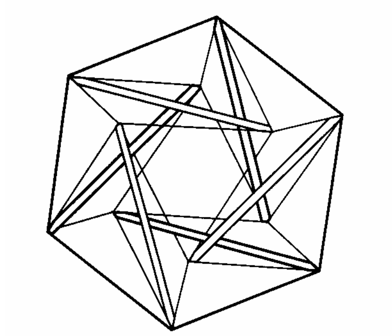
We distinguish between different information systems and networks which serve communication. The **neural network** transmits encoded information. Since the nervous system works with frequency modulation, a loud noise does not cause a larger deflection in the vestibulocochlear nerve; instead it causes a higher number of deflections which is interpreted as a loud noise by the temporal lobe. Independent of the kind of information which is sent, it is always encoded – as in “Morse code” – and has to be deciphered correctly. The emergence of a faulty hearing perception can be compared to the limited coding capacity of the eye when, for example, the palm is pressed against the closed eyelid until we “see” light. The pressure alone stimulates the optic nerve which passes the information on to the brain where the incoming signal is interpreted as light. Therefore the signal “pressure” is erroneously decoded as “light.” (Myers, 2004, p. 36)

The second communication network is the **circulatory system** which carries chemical information in a liquid medium through the body. (Myers, 2004, p. 36) The blood and vascular system has a vital function in supplying the tissue and each cell with oxygen and nutrients and taking away used substances. There is a fluid transition to the lymphatic system and to the cerebrospinal liquor. If there is an imbalance in this system, the vitality of a human can be reduced considerably. (Dräger, 2000, p. 8)

A venous stasis can change the situation drastically. For example, a slowed down venous drainage can cause cerebrovascular obstruction in the blood flow through the brain. The dural sinuses are very sensitive because they are thin-layered and not held by any musculature. Above all they are easy to compress. 95% of the cranial venous drainage is done through the jugular foramina, located between the temporal and occipital bone. In cases of structural disturbance there can be a stoppage causing hyperaemia, oedema, stasis, contraction of the cervical musculature and tensions in the fascia and dura. A venous stasis, no matter whether mechanical or caused by reflex, causes a change in the chemistry, retention of metabolic products, a lessened alkalinity and a heightened toxicity. This can lead to a gradual failure of the axonal conduction and synaptic transmission. However, we can say that a normal, liquid surrounding is of the utmost importance for a good homoeostasis. (Nusselein 2000) Considering the hypotheses on the origin of subjective tinnitus (see chapter 2.4.1), a disturbed homoeostasis could be the reason for the ill-coding in cases of tinnitus.

The third system, the **fascial network**, forms the "material human". This system transmits the mechanical information but it also represents vitalising and spiritual aspects. Regarding the fascia Stark (2006) cites Still (1899): "If they work, we live, if they fail, we shrink or swell and die." (Stark, 2006, p. 166)

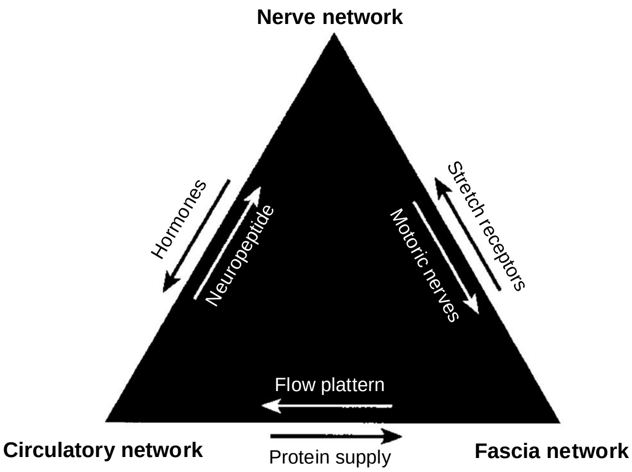
Here, we speak of lesion chains which transmit the interplay of tension and compression along the collagen fibres of the fascial network. (Myers, 2004, p. 50) Above all it is the temporal bone which is essential for the statics, a sensitive equilibrium which is kept in balance by the tensegrity principles of the myofascial and osseous system. (Dräger, 2006, p.19) It can be explained by the Buckminster-Fuller "tensegrity model": the compression elements (i.e. the bones) press outwards against the tension elements (i.e. myofascial structures) which press inwards. As long as both forces are in balance, the structure is stable. A rise of tension in one element means an increased tension for all elements of the entire structure, even those on the opposite end. The elastic structures become more stable, the more they are stressed. The tensegrity model comes very close to the visions of Still (1899). (Myers, 2004, p. 50-51)



Ill. 10 "Tensegrity model" (Myers, 2004, p. 48)

If we pull at one point, it will spread over the entire network at the speed of sound, from fibre to fibre, from cell to cell. It becomes problematic when fibres pass on compensations in the body structure. This rhythm is considerably slower, so this year's pain in the neck accompanied by a ringing in the ears can be built up on last year's pain in the back which again resulted from a problem in the iliosacral area three years ago which had emerged after a twisted ankle. Meanwhile this entire "pattern" has settled in the neuro-myofascial network. (Myers, 2004, p. 38)

On the other hand typical "postural patterns" caused by habits or sustained emotions can be fixed in the same way. Thus the depression pattern, for example, which often accompanies tinnitus, starts with the musculature and reacts with the nervous system. Myers (2004) writes that the musculature is the “messenger” of the nervous system for the fascial network in the same way as the stretch receptors are the “messengers” of the fascial network for the nervous system. Furthermore, the chemical balance of blood and body liquids is changed by the lessening of breathing, the oxygen level is reduced, the cortisol level increases. When after some time the new postural pattern is fixed by the adaptation of the fascial structures, we can assume that an antidepressant alone cannot be the solution of the problem. (Myers, 2004, p. 37-39)



Ill. 11 Relationship of the holistic networks (Myers, 2004, p. 39)

5. General osteopathic treatment in the case of tinnitus

The osteopathic approach shows that it is not possible to treat all patients with standardised procedures. Dräger (2000) cites Still (1899): “I do not instruct the student to punch or pull a certain bone, nerve or muscle for a certain disease, but by a knowledge of the normal and abnormal, I hope to give a specific knowledge for all diseases.” (Dräger, 2000, p. 11)

Osteopathy is a functional method of treatment, which has the aim of finding and relieving lesions in all functioning systems of body so that the patient can be given a basis upon which to self-regulate his/her individual functional balance, thus regaining his/her health. This philosophy is expressed in the principles of Still (1986), the founder of osteopathy: (Ligner, 1993, p. 23-34)

Life is movement

Structure rules function

Function forms structure

The body functions as a whole

The law of the arteries: free circulation is the basis of life

Activation of the self-healing mechanism

The general well-being of the patient and also any irregularities in examination results should be dealt with osteopathically according to these principles. Any predominant restriction or lesions that cause an imbalance in the “primary respiratory mechanism” (PRM) or any other system, which result in the undermining of a function, should be recognised in particular. The maximum freedom of body fluid flow has priority so that the patient can return to a state of vitality enabling optimal movement and therefore providing a healthy quality of life.

In osteopathic treatment various body systems are brought together. With reference to the cranial symptom of tinnitus I would like to begin with the cranial system which, in the final analysis, reaches right into every cell of the human body.

5.1. Osteopathic cranial models with regard to tinnitus

The cranial system handles the PRM, which covers the entire body in physiological terms. This primary respiratory impression reveals the vitality of the patient. (Liem, 1998, p. 15-16)

The motility (inherent movement) of the brain and spinal cord and the fluctuation of the fluid create the momentum for the “cranio-rhythmic impulse” (CRI). This is a cranial movement of expansion (inspiration) and retraction (expiration) with a frequency of 6-14 cycles per minute. Sutherland (1967) compares this movement with the ebb and flow of the ocean. (Liem, 1998, p.16) This rhythm is connected to the periphery through the homogeneous system of the intercranial and interspinal membranes (reciprocal tensional balance between falx cerebri, falx cerebelli, tentorium cerebelli and spinal dura mater). It is transferred so that the movement between the cranial bones and the instinctive mobility of the sacrum between the iliums can be registered. (Arlot, 1997)

In biodynamic cranial osteopathy further slow rhythms are described. For instance, the "long tide" according to Jealous (2006), a rhythm that spreads itself beyond the body at 2.5 cycles a minute and in comparison to CRI is not influenced physiologically or through any body dysfunctions. The most thorough healing processes are possible through becoming aware of these rhythms. (Shaver, 2006)

The cranial system is transmitted to the periphery via channels. According to Magoun (1976) these channels are neural structures, facial nerve envelope, connections to the myofascial system, the connection of the fluid with the arteries, veins and lymph systems and their transmission through the mechanical articular connections. (Magoun, 1976, p. 26)

As all physiological processes are perceived and controlled by this system, it serves to maintain functional balance on an electrophysiological, piezoelectrical, electromagnetic, hormonal, biochemical and psychological level. Thus the cranial rhythmic impulse represents a dynamic metabolic interchange in every cell. (Magoun, 1976, p. 36)

The expression of movement of the cranial system and the primary respiratory mechanism (PRM) is perceived as a rhythmical variation of tension. It is possible for the therapist to make an impression upon this movement because of the flexibility of the tissue and the malleability of the bones. (Dräger, 2000, p. 10) Movement in the cranial system can develop into a disturbed pattern through various conditions: for instance birth trauma, fever, meningitis, state of shock, psychological imbalance, blow to the head, injury to the coccyx and others.

On the other hand Arlot (1997) maintains that cranial lesions can play an important role because they influence both the central nervous system and the pituitary gland. This way the cranium answers with sensations of many chronic troubles, such as psychological and mental stress, that are not caused by organic problems. (Arlot, 1997)

An osteopath treating tinnitus takes particular notice of the conditions in the area of the temporal bones and the surrounding connected structures. An intracranial connection is established to the dura (reciproce tension membrane). The tentorium cerebelli plays an integrating role in particular in that it hangs between both temporalia and together with the common insertion of falx cerebri along the sinus rectus, offering a centre, the Sutherland Fulcrum. (Magoun, 1976, p. 27)

The cranial movement of the temporal bone follows the physiological movement of the synchondrosis sphenobasilaris (SSB). The falx cerebri rolls inwards during inspiration of the primary breathing. The os temporale is pushed outward by the increase in SSB (occiput backwards, sphenoid forwards). The superior part of the petrosus bone is also lifted, stretching all the membranes. At the same time the front part of the tentorium is pulled forwards and upwards, so that the temporal bone completes an external rotation through the virtual Sutherland (1948) axis that leads through the pyramid point of the petrosus bone and the jugular joint surface. During expiration the opposite occurs, an internal rotation of the temporal bone. (Arlot, 1997)

The temporal bone has to follow the different directions between both bones, the occiput and the sphenoid, by PRM and also integrate their contradictory movements. When there are lesions in this area, bordering structures are irritated thus influencing their function. The patient is also hindered due to the restricted vitality.

5.1.1 Rotation lesion of the os temporale influences the Eustachian tube

Magoun (1976) differentiates between the high and low frequencies of tinnitus from a structural point of view. The state of the Eustachian tube can be of osteopathic importance. The lateral third of the Eustachian tube lies within the pars petrosa of the temporal bone. The remaining cartilaginous two thirds hang from the lower edge of the bone. The osseous part is normally open all the time while the rest remains closed (except when yawning and swallowing). This way balance of pressure is achieved on both sides of the eardrum. A small rotation lesion of the temporal bone can change these physiological relationships. An external rotation of the os temporale can leave the Eustachian tube continuously open, whereby the patient usually complains of a low-pitched drone. An internal rotation lesion can lead to the narrowing or even closure of the Eustachian tube where high-pitched humming or even howling can be heard. (Magoun, 1976, p. 300)

This sound may be synchronous with the pulse. Magoun (1976) believes that these sounds are generated because of the resulting friction of the blood rushing around the elbow bend in the carotid artery in the pars petrosa which is separated from the inner ear only by a thin osseous plate. Normally we are not conscious of this sound unless we put an empty shell to our ear and apparently “hear the sea”. However it becomes obviously apparent with the restricted circulation and oedema caused by a lesion. Correction of the temporal rotation and release of the cervical fascia attached below may be of benefit, provided there is not too much sclerotic development. If such lesions are not dealt with early enough, they can pave the way for tinnitus. (Magoun, 1976, p. 300)

In connection with this it is worth mentioning the pilot study of Mayer (2003). She examined the effectiveness of the osteopathic tuba auditiva technique in patients who had acute tinnitus with or without auditory impairment. All together 47 patients with severe tinnitus were involved in the study. During the maximum ten-day hospital stay all patients received the usual standard medical treatment. At the same time the osteopathic group of 26 patients were treated three times with the Eustachian tube technique while the control group of 21 patients received a non-specific physiotherapy. The final results of both groups revealed an overall improvement. It cannot be assumed, therefore, that the use of the Eustachian tube technique in the case of patients with acute tinnitus, with or without auditory impairment, has any significant effect. It revealed the difficulty in testing a chosen osteopathic technique. (Mayer, 2003) Nevertheless one can thus assume that the Eustachian tube alone is not responsible for the origin of tinnitus so that general osteopathic treatment in the light of the osteopathic principles, according to Still (1986), could be more effective. Resch (2006) comments on this study saying: “It would be of interest to discuss whether the treatment of a symptom would have more potential success when dealt with on an open, result-based, procedure than a restrictive treatment based on a pre-programmed technique.” (Resch, 2006, p. 7)

5.1.2 Entrapment neuropathy of vestibulo-cochlear nerve

Both parts of the vestibule-cochlear nerve (N. VIII) run through the facial canal to the internal acoustic meatus over the sensitive zone of the jugular tuberculum to the posterior horn. In the case of structural damage the nerves can be affected by an “entrapment neuropathy”. The definition of entrapment neuropathy is in damage or mechanical injury caused through the pinching of the adnexes resulting in the loss of normal movement. This causes stress which results in a change in the biochemistry and bioelectricity. Excessive sensibility of the receptors or an interference of transmission can result through a structural lesion in the cranial system. This can result in a disturbance and change the function of the central nervous system. For instance, an abnormal arteriosclerotic anterior inferior cerebellar artery, that has twisted above, below or between the facial nerve and vestibule-cochlear nerve can put pressure on the nerves and undermine their function. Abnormal dural tension can also cause dysfunction. The most obvious examples of entrapment neuropathy have a direct connection to the auditory organs and organs of balance (Nusselein, 2000) where the origin of tinnitus can be explained.

5.1.3 The functional relationship to the liquor system

The function of the vestibule-cochlear nerve can be traumatically disturbed by high endolymphatic pressure and asphyxia of the labyrinthi organs. The proximal third of the saccus lies in the dural part of the vestibular aqueduct, so that a functional relationship is maintained to the spinal fluid. This fluid can, however, be influenced by a non-physiological membrane tension caused by a lesion of temporal bone, which can diminish normal function. (Nusselein, 2000)

5.1.4 Postcervical sympathetic syndrome

Tinnitus is often combined with the postcervical syndrome in the form of rear headache, impaired vision, dizziness, neck tension and periarthritis. (Magoun, 1976, p. 300)

Plothe (2006) writes that it is comprehensible that a disturbance in the function of the cervical spine can be seen pathophysiologically in conjunction with tinnitus because of the connection between the cervical spine and the central auditory system. These afferent tracts come mainly from the C2/C3 radix. The cause of this malfunction can be both traumatic and compensatory due to a dysfunction in other segments of the spine or even the pelvis. (Plothe, 2006, p. 28)

Furthermore Plothe (2006) explains the effectiveness of mobilising the upper cervical spine because the nucleus of the trigeminal nerve that innervates the tensoris tympani muscle, descends to the level of the C2. (Plothe, 2006, p. 29)

5.1.5 Traumatic lesions

Traumatic lesions in the area of the temporal bone and occipital bone can influence the movement of the SSB enormously. For instance, the cranial system can be obstructed causing change or dysfunction in the auditory system. The temporal bone is the mediator between the outer myofascial tensions, via the insertion of the temporal aponeurosis, and the inner membranous tensions, via the solid insertion of the tentorium cerebelli at the pars petrosa of temporal bone. The dural membranes are attached to the cervical fascia and thus to most of the rest of the body. As well as being attached to the sphenoid, occiput and temporal the fascia also inserts at the zygoma, mandibulae and pharynx. Various states of tension can be transmitted from outside to the interior via the insertion of the pharyngeal raphe (connection to the mediastinum and pharynx). Nerves, vessels and the lymph drainage can become irritated when an imbalance occurs. (Nusselein, 2000)

5.1.6 Jaw and dental problems

The temporal bone forms the stress susceptible joint socket of the jaw which is an immediate neighbour of the auditory canal. A dysfunction resulting from trauma, the extraction of a wisdom tooth, patterns of tension through stress and so on, have a direct effect on the function of the temporal. The results can be denture abnormalities, both uni- and bilateral, a growth disturbance of the teeth, bruxism, and a cracking sound of the meniscus of the jaw. Because of the close connection to the cranial nerves these dysfunctions can result in sight impairment, taste impairment but above all in auditory abnormality such as tinnitus and disturbance of balance. (Liem, 2003, p. 86)

In the case of tinnitus one often finds during palpation a unilaterally painful, tense pterygoidal muscle, which can directly irritate the meniscus. However, the strong extra-cranial insertions of the stress susceptible temporal muscle and masseter muscle at the galea aponeurotica are of importance. This can lead to compression on the occipitomastoidea suture or parietomastoidea suture (see chapter 3.1). (Plothe, 2006, p. 28)

Liem (2003) describes ligament connections that can have a direct influence on the transmission of sound waves in the middle ear when there is a dysfunction of the temporomandibular articulation. The anterior malleus ligament leads from the anterior process of the malleus to the petrotympanic fissure. A number of fibres lead to the sphenoidal spina and together with the sphenomandibular ligament to the ramus of mandibula. The ligament of Pintus (irregular occurrence), leads from the malleus through the petrotympanic fissure to the mandibular caput. (Liem, 2003, 87)

5.1.7. Vessel problematic

Still (1986) teaches that all vessels that lead to and from the heart have to be freed of all obstacles. No nerve can fulfil its task unless it is well nourished. (Still, 1986, p. 99)

5.1.7.1 Reduced circulation

The internal carotid artery is responsible for the most important blood supply to the brain. Apart from that it leads the pulsating heart beat to the petrosus apex of temporal. Both a dysfunction in the fluid as well as through the fascial loge of the carotid artery can have a strong restrictive influence on the rotation movement of the temporal bone within the PRM.

Deformation or compression of the foramen magnum may influence vessels such as the vertebral artery, posterior spinal artery and basilar truncus, which can cause vertigo. (Arlot, 1998)

5.1.7.2 Problems of congestion

A release in the cervicothoracal diaphragm (thoracic outlet syndrome) and in the thoracic diaphragm assists not only the veins but also the lymph drainage from the head.

Hypertension of the infrahyoidal muscles can constrict the internal jugular vein, and hinder the flow in the veins. (Liem, 1998, p. 379)

The drainage from the cranium through the veins is irritated by any compression of the jugular foramen. A backflow in the cerebral sinuses can also be the result of an increase in dura tension. (Arlot, 1998)

As already mentioned in chapter 4.3 a venous stasis has the effect of changing the chemistry, causing retention of metabolic products, alkaline decrease and raised toxicity, resulting in a gradual failure of the axonal conduction and synaptic transmission.

5.1.8 Stress of the modern world

The most common result of osteopathic examinations these days is an incessant contraction in the area of the craniocervical spine. It could be said that it reflects the stress of the modern world resulting in a loss in cranial flexibility and a growing rigidity in the structures. (Nusselein, 2000)

Plothe (2006) writes that functional studies have proved that the choroid plexus, situated in the side ventricles, has a sympathetic supply, the production of which, under stress, can be reduced by 50%. If one takes into account that the organ of Corti has no blood stream of its own, and depends on the endolymph for its nourishment, this could be seen as a further pathophysiological reason for the way in which the inner ear is supplied and the manner in which tinnitus arises. (Plothe, 2006, p. 27)

In the treatment of tinnitus it is of significant importance to achieve balance in the case of non-physiological conditions of tension and a release of cranial motility of the osseous structure, the central nervous system and the ventricles. This is to ensure the functioning of the endolymphatic mechanism between the endolymphatic duct and the subarachnoidal space and also to ensure the drainage of the inner ear via the petrosus sinus and sigmoid sinus. (Plothe, 2006, p. 29)

5.2. Osteopathic visceral models regarding tinnitus

The visceral system corresponds to the inner organ system in that it reveals an interrelationship between structure and function among the internal organs, which is at least as strong as that among the constituents of the musculoskeletal system. There is the hypothesis that an organ or viscera in a good, healthy condition has physiologic motion. This movement depends, on the one hand, on the membranes that surround the organs, and on the other hand, on the fascia, ligaments and other tissue structures that bind the organ to the rest of the organism. These physiological movements are divided into two components: first the visceral mobility which is the movement of the viscera in response to voluntary movement or to movement of the diaphragm in respiration and then the visceral motility, which is the inherent motion of the viscera themselves. Any restriction, fixation or adhesion to another structure serves to imply the functional impairment of a specific organ. (Barral, 1997, p. 5)

The inner organs are responsible for the ingestion and absorption of nourishment and oxygen as well as the excretion of waste products and poisons. The whole metabolism depends on the functioning balance of these systems. The prerequisite for this is mobility, for instance the peristalsis of the digestive system, the excretion of fluid through the smooth muscular structures of the efferent ducts of the glands and the potential for the organs or shift of organs via physical movements and breathing. A diminished function of the organ can be caused through compression and congestion of vessels and nerves.

5.2.1 Digestion

Dräger (2006) explains a visceral connection to the digestion in that “the intestine begins with the teeth” and passes through the pharynx. Every swallowing action pulls towards the temporal because of the attachment of the visceral loge at the temporal and the connection of the floor of the mouth (digastricus muscle, stylohyoid muscle) to the mandibular and hyoid bone. In this case any visceral ptosis can pull at the synchondrosis sphenobasilaris, and also at the temporal bone. (Dräger, 2006, p. 20)

5.2.2 Kidneys

Dräger (2000) describes an important relationship between tinnitus, the kidneys and the suprarenal glands in connection with their influence on circulation. Circulation is influenced by rheology, the regulation of the fluid household, and also controls the volume of blood pressure. This takes place with the help of the renin-angiotensin-aldosteron system and the adrenalin supplied by the suprarenal glands. (Silbernagl, 2003, p. 170) Furthermore erythropoetin affects the production of erythrozytes. The kidneys have an effective control over the condition of the blood through their strong contribution to circulation of 20-25% heart/time volume. (Silbernagl, 2003, p. 150) The influence on the fluid household appears to be of significant interest in that the endolymphatic sac, which functions as a reservoir or pressure balancer, serves towards a healthy functioning of the inner ear. For this reason benign intracranial hypertension can play a significant role in the case of tinnitus. (Dräger, 2000, p. 20)

Barral (2006) writes that stress in the form of sound shock waves vibrate through the body. If the kidneys are affected, the excretion system and in particular the vessel system contract and a function disorder may be the result. (Barral, 2006, p. 21)

It is interesting to note that the kidneys and the cochlea are not only connected in the case of specific illnesses but also have a similar anatomical and ultra structural organisation. For this reason kidney operations which have also healed of tinnitus have been described. (Plothe, 2006, p. 27)

Barral (2005) explains that the most significant kidney disorder is nephroptosis. The kidneys are not only restricted through the ptosis or pathological fixation in its movement (motility and mobility), they can also be affected by information concerning tension via the fascial pull which can be transmitted to the cranium. In the case of nephroptosis grade 1 the intercostal nerve, which is bordered by the pararenal adipose tissue, the aponeurosis of lumbal quadratus muscle and the posterior part of the renal fascia, can become irritated. Furthermore there is an increase in the tension of the diaphragm and reduced expansion and depth of breathing in this half of the thorax. (Barral, 2005, p. 170-173)

In the case of nephroptosis grade 2 the kidneys move downwards along the "splint of psoas muscle". The lower edge shifts backwards so that the external rotation emerges. An intravenous urography that makes the hilus vessels visible allows this external rotation to be seen clearly. According to Barral's (2005) opinion the intensification of tension on the hilus vessels occurs as a result of the vessel spasm that results from the external rotation of the kidney. (Barral, 2005, p. 173)

When the kidneys move further inferior and anterior one refers to grade 3 nephroptosis or the "pelvic kidney". The kidney finds itself in a more internal rotation because it is no longer under the influence of the psoas muscle. In this case the spasm seems to occur in a reduced amount. Nevertheless severe pain can be experienced in the capsule of the knee joint through an irritation of the femoral nerve. This maintains a spasm of the psoas muscle that on the one hand can turn the lower leg outwards and change the axis of the leg and on the other hand can continue the fascial tension onto the cranium. (Barral, 2005, p. 173-175)

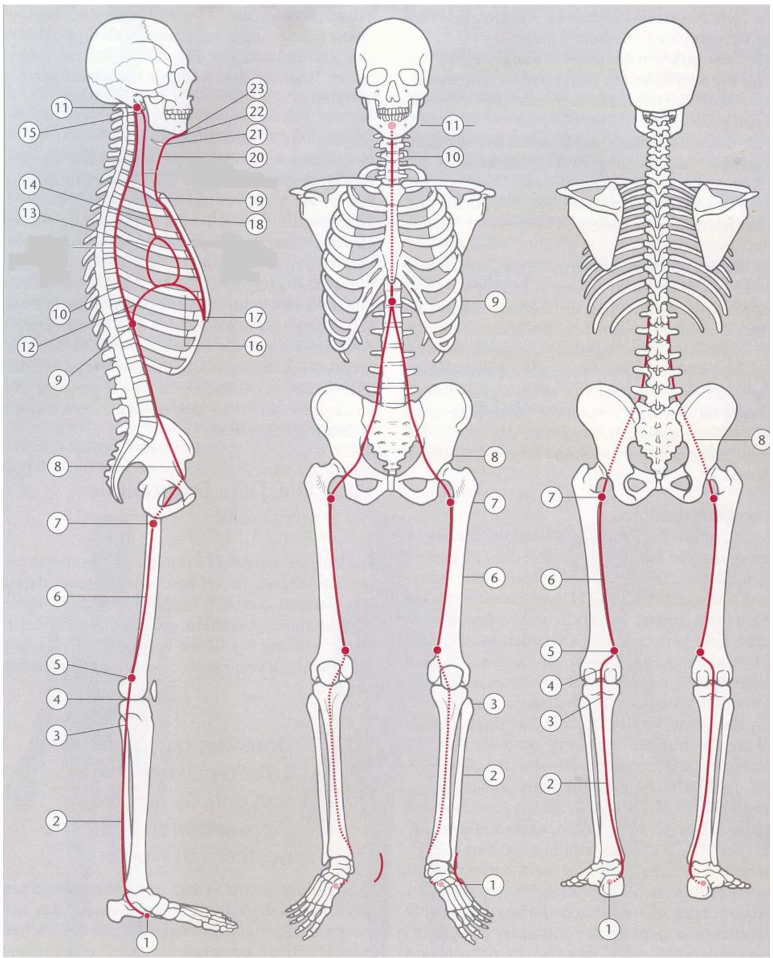
5.3. Osteopathic fascial model with regard to tinnitus

The fascial system links the individual systems with one another. The myofascial system is the main mediator on the surface. In the interior one speaks of the deep visceral fascia that surrounds the visceral system. All the thoracic viscera hang by fascias from the subcrania, forming a continuation through the foramen magnum to the cranial dura. (Nusselein, 2000)

Furthermore a recent study of Schleip et al. (2006) reveals the ability of the fascias (both the epimysial as well as the visceral fascia) to contract and expand. Histological examination showed that fascias contain contractile myofibroblasts and thus have an influence on the musculoskeletal biochemistry. The presence of too many myofibroblasts could mean a tendency for the tonic muscles to chronically contract which would explain heightened stiffness when resting. Apart from this the fascial tonus is not only regulated through cell messengers but also by mechanical stimulation. A myofascial release could help the patient out of this pattern. (Schleip, 2006, p. 19-20)

5.3.1 Deep visceral fascia

With regard to tinnitus the deep fascia that connects the visceral system to the cranial membranes is of significant osteopathic importance. Myers (2004) describes a deep fascia line as the "myofascial core" of the body.



Ill. 12 Deep frontal line (Myers, 2004, p. 184)

The lowest section forms, on the plantar side of the tarsal bones (1), the posterior tibial muscle, the long flexor hallucis muscle and the long flexor digitorum muscle (2), the connection to the deep posterior part of the compartment of the lower leg (3). This myofascial line crosses on the upper end of the compartment at the posterior side of the knee in the form of the popliteal fascia (4), that originates out of the posterior lamina of popliteal muscle, the neurovascular fasciculus with tibial nerve and popliteal artery, as well as from the dorsal fascial capsule of the knee joint. The line continues in the posterior area over the tuberculum adductorium of the medial femoral epicondyl (5), then via the posterior intermuscular septum in the adductor magnus muscle continuing to the ischial ramus into the fascia of pelvic floor, the levator ani muscle, the internal obturatorial fascia and the anterior sacral fascia. Anterior the line passes from the femoral linea aspera (6), as insertion of long/short adductor muscle, to the sail-like form of the anterior intermuscular septum onto the trochanter minor (7), then through the neurovascular fasciculus and various lymph nodes that run through the iliopsoas muscle (8). The fascia that covers the iliacus muscle is connected to the fascia of the anterior surface of the lumbal quadratus muscle that lies behind the insertion of the psoas muscle which leads to the transversal processes of the lumbar spine (9) all the way to the 12^{th} rib.

The posterior section works its way forward along the anterior longitudinal ligament (10) including the long capitis muscle, long colli muscle, anterior rectus capitis muscle and the scaleni muscles until the basis of the occiput (11). (Myers, 2004, 200)

The anterior section runs from the anterior parts of the diaphragm (16) at the medial side of the subcostal cartilage and the xiphoid process (17) in the endothoracic fascia (18) up to the sternal manubrium (19). From this point the line runs alongside infrahyoidal muscles (20) (sternohyoidal muscle, sternothyroidal muscle, cricothyroidal muscle) and the omohyoidal muscle until the hyoid bone (21). After this the digastricus muscle (22) runs on the one hand in cranial posterior direction to the temporal mastoid process, thereby creating a connection to the neurocranium; on the other hand it runs in anterior cranial direction accompanied by mylohyoidal muscle (22) and glenohyoidal muscle (22) to the mandibula (23), forming the base of the tongue. An indirect connection to the jaw joint is formed by the masseter muscle and medial pterygoidal muscle. The temporal muscle leads up to the wide insertion area on the temporal bone. The fascia of temporal muscle leads under the galea aponeurotica where it conjoins with the superior myofascial lines. (Myers, 2004, p. 204-206)

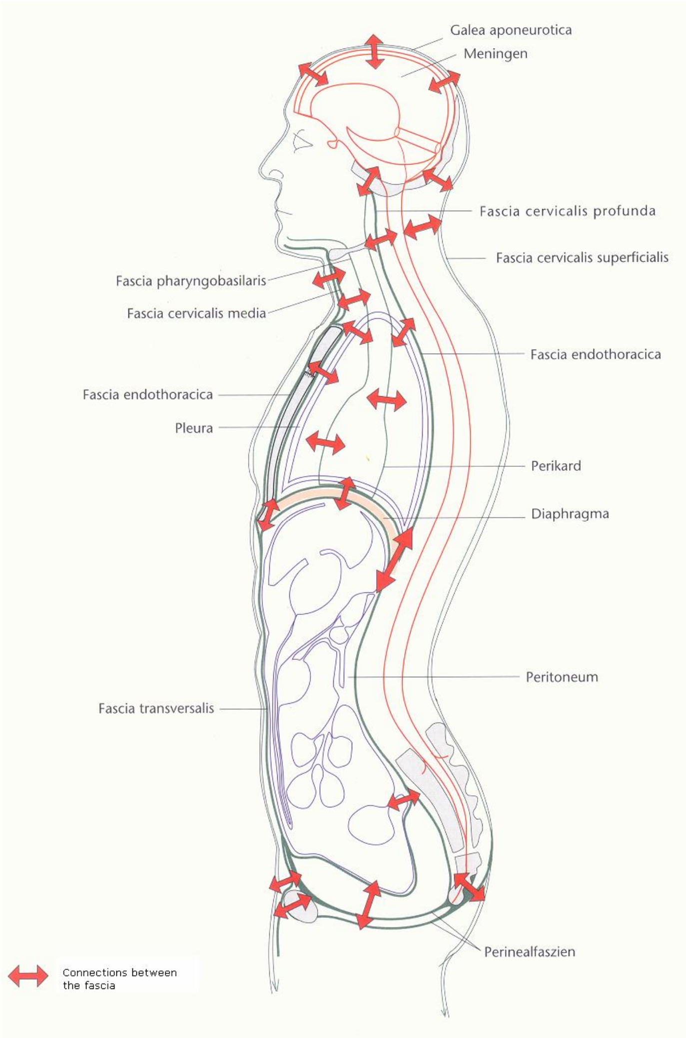
The fascias of the mid-axis create a connection to the visceral system. At the thoracolumbal passage the upper end of the psoas muscle joins the crura of the lumbal section of the diaphragm (12). This critical point of connection lies close behind the kidneys, suprarenal glands and the solar plexus. The area of thoracolumbal spine is significant in that it connects the upper and lower parts of body; it connects breathing and walking movement, assimilation and elimination. (Myers, 2004, p. 197) Excess tension in the crura of the thoracic diaphragm can lower the venous blood flow to the heart, causing congestion. (van Dun, 2006)

The centre tendineum (12) connects fascially to the pericardia (13) and the mediastinum (14), including the parietal pleura and the lung bronchia as well as the oesophagus. (Myers, 2004, p. 202-204)

The middle-axis fascia continues in cranial direction in the pharyngeal fascia and pharyngobasilaric fascia that inserts at the occipital basilar part in the area of Tuberculum pharyngeal (15), at the inferior side of temporal petrosus part, at the posterolateral part of the basis of pterygoidal process, at the inferior fibrous wall of auditory tube and at the pterygomandibular raphe. Now the palatin fascia, pterygo-temporo-mandibular fascia and interpterygoidal fascia build a connection to the subcrania and to the dura mater. (Paoletti, 2001, p. 81-82) The attachment of the tentorium cerebelli is fundamental because the temporal is connected via the dura to the deep fascia ("core link") and the external fascias. (Arlot, 1997)

This model of Myers (2004) should clarify that lesions along the deep fascial line can have a direct influence upon the function of the temporal. In particular, every visceral ptosis affects a fascial pull on the temporal bone because of the insertion of the pharynx.

The following diagram shows the order of the fascia. However, it should also make clear that a lesion via the communication (see arrows) between the fascias and its connection to the meninges can be transmitted to the cranium. (Paoletti, 2001, p. 111)



Ill. 13 Communication between the fascia and the connection to the cerebral membranes (Paoletti, 2001, p. 111)

From an embryological point of view the upper end of the deep frontal line forms a physiological junction. The connection to the sphenoid is established via the larynx-hyoid-complex. The hypophysis ("Master gland") that regulates the hormone system lies within the sella turcica of the sphenoid. The hypothalamus-hypophysis-axis that is responsible for the central distribution of body fluids and the body of nerves is of primary ectodermal origin. The synchondrosis sphenobasilaris (SSB) lies immediately below and behind it and in connecting the sphenoid bone and the occiput bone is regarded as a central fulcrum of craniosacral movement. It represents a central structure of the mesodermal body to which the collagenic network belongs and all the muscular impulses that produce the fluid waves of the liquor. Immediately behind and below the SSB the upper section of the pharynx finishes as the central and original gullet of the endodermal tube. (Myers, 2004, p. 208)

5.3.2. The superficial myofascial system

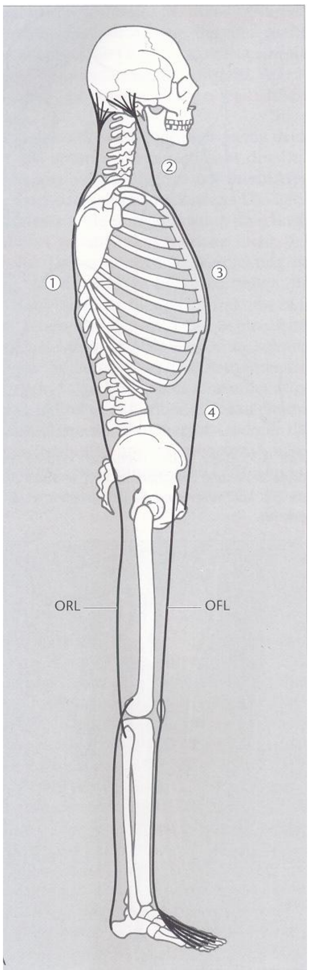
The locomotor system is treated in conjunction with the function of the joints as well as the tension and relaxation of the muscles and the flexibility of the connective tissue. There are interchangeable relationships between static and dynamic. A prerequisite for a healthy locomotor system is movement. Myofascial lesions can be transferred to other parts of the body by lesion chains, so that a symptom can appear in quite a different area from where it originates.

On the outside the auditory system is connected with the myofascial system, the anterior, posterior and lateral muscle chains via the galea aponeurotica. Myers (2004) describes typical lines of the myofascia that hang along behind one another as “anatomy trains” that can continue to be transmitted lesions:

5.3.2.1 Imbalance between the superficial dorsal and frontal line

The superficial dorsal line (1) connects the complete posterior surface from the plantar surface of the phalanges of the toes all the way to the eyebrows. This dorsal line supports posture all day long. This is marked through the particularly strongly developed dorsal tissues and fascial sections. One only has to think of the strong Achilles tendon, the ischiocrural muscles, the sacrotuberal ligament, the thoracolumbal fascia and the “cables” of spinal erector muscles that provide a connection with the central axis and occiput by the linea nuchalis. (Myers, 2004, p. 69)

The superficial frontal line transmits information from the dorsal surface of the phalanges of the toes to the mastoid process and asterion. The right and the left frontal line meet at the level of lamdoid suture creating a functional loop. (Myers, 2004, p. 113) Its overall function in this position lies in that it is an antagonistic opposition to the superficial dorsal line in order to maintain a sagittal balance. The fast reactions of the muscles and the flexibility of the myofascia of the frontal line are always ready to protect the soft and sensitive frontal areas of the viscera (4). (Myers, 2004, p. 97-98)



Ill. 14 Superficial dorsal- and frontal line (Myers, 2004, p. 99)

In the case of chronic imbalance between these two lines, unphysiological tensions and typical poor posture can develop. One can assume that these bad habits can develop because in the area of the asterion on the galea aponeurotica, the myofascia meld with one another so that the temporal bone and with it the auditory system is irritated in its function.

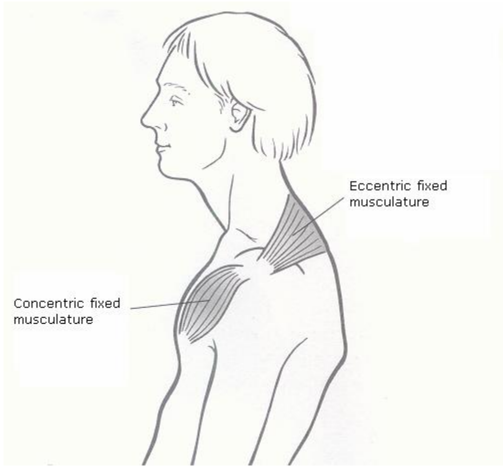
The origin of a lesion lies often in the area of the feet. Chronic tension in the dorsal line is to be found in the case of poor posture where there is a tendancy to lean forward from the feet to the pelvis. As a result, the heel is subsequently pressed forwards into the subtalare joint and the tibia-fibular complex can thus be pushed towards posterior, opposite the talus. This tension is transmitted via the calcaneus onto the Achilles tendon and gastrognemic muscle. The result of this can lead to a contraction of the ischiocrural muscles, lumbar lordosis and hyperextension of the upper cervical spine which is resistant to any treatment. (Myers, 2004, p. 72-75)

At the front the tension in the feet can be transferred to the knee via the extensoris muscles of the toes and the tibial muscles. Furthermore this tension can be transmitted onto the pelvis via the femoral quadriceps muscle (rectus muscle). (Myers, 2004, p. 101-104) The line runs over the abdominal rectus muscle to the fifth rib and then via the sternochondral fascia and sternal muscle to the sternal manubrium (3). On the superior anterior end this forms a firm insertion area for the sternal caput of the sternocleidomastoid myofascia. This also connects with the sternal muscle that emerges under the pectoral fascia. Then the sternocleidomastoid muscle (2) leads upwards in a lateral and posterior direction to the temporal mastoid process where it fans out into the lateral, posterior parts of the galea aponeurotica. (Myers, 2004, p. 109-111)

The linea nuchalis creates the antithesis in the dorsal with the "suboccipital star", which are the deepest muscular layers. The minor/major posterior rectus capitis muscle and the superior/inferior obliquus capitis muscle as a functional unity is significant for the aperture of the complete dorsal line. The connection between eye movements and coordination can be established because of the vast number of stretch receptors in this tissue. Patients often display a typical posture that has developed either through habit or as a result of anxiety. Such patients appear dejected because of an increased kyphosis in the thoracal spine and drawn-in head. This results in a hyperextension in the upper cervical spine and a translation of occiput in anterior direction opposite the atlas, due to the sternocleidomastoid muscle, which suddenly springs towards the back of the head. (Myers, 2004, p. 85-86)

Problems arise when long-term poor posture has developed, for instance in the case of a "military posture" where the dorsal line appears like a compressed bow. The frontal line is stretched and overstrained through which the viscera are pushed forward. The opposite pattern is the overstrained collapsed posture: the lumbar spine is flattened; the rib cage is pulled caudally by the abdominal rectus muscle which pushes the ribs apart causing diminished breathing. The sternum and sternal muscle transmit this characteristic of tension to the sternocleidomastoid muscle which in turn pulls the head caudally. As well as its extension task the dorsal line has to support the back of the body and work against the downwards pull of the frontal line. As a result of this an extremely fibrotic and caudally fixed fascia emerges along the dorsal side of body. (Myers, 2004, p. 116-117)

The following illustration shows that an imbalance between the dorsal and frontal line inevitably leads to a dysfunction in the shoulder-arm-complex. An eccentric fixation on the dorsal side can cause chronic pain due to constant myofascial pull at the subcrania. (Myers, 2004, p. 117)



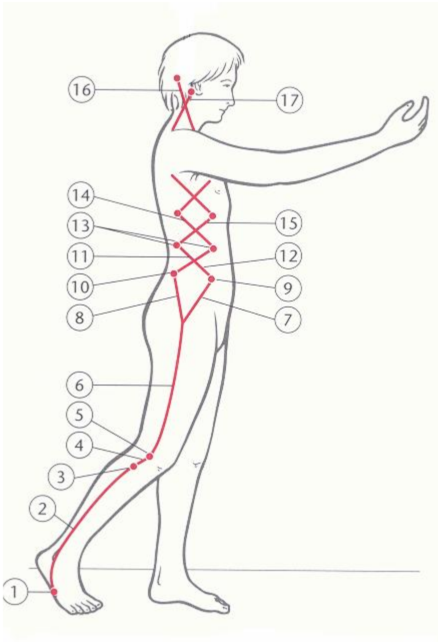
Ill. 15 Typical posture because of an imbalance between concentric and eccentric fixed musculature (Myers, 2004, p. 122)

The superficial dorsal line shows a relationship with the deep dorsal arm line via the rhomboid muscles, the levator scapulae muscle and the muscles of rotator cuff that play an important role in the balance in the control of the shoulder joint. (Myers, 2004, p. 161-163) The trapezius muscle makes a connection to the superficial dorsal arm line possible. The trapezius muscle runs from its broad insertion area from the external occipital crista until the spinal process of Th12 to the scapular spina, to the acromion and to the lateral third of the clavicula. Here the tissues of the trapezius muscle mesh with those of the deltoid muscle that form a roof over the shoulder joint. All these pulling lines of the trapezius muscle and deltoid muscle run together on the tuberculum deltoidea humeri and meld with the tissue of lateral intermuscular septum that is attached to the humeral lateral epicondyl. This connection is of significant osteopathic importance because when natural balance is lost in the shoulder-arm-complex; tension and dysfunction can result not only in this area but also continue in its direction to the cranium where it can reach right up to the galea aponeurotica. (Myers, 2004, p. 165-166)

The connection to the deep frontal arm line starts with the minor pectoral muscle embedded in the clavipectoral fascia which runs underneath the major pectoral muscle from the clavicula to the armpit. It includes both the minor pectoral muscle as well as the subclavius muscle and reveals a connection to the neurovascular fascicle and the lymph vessels. (Myers, 2004, p. 155-157)

5.3.2.2 The lateral line - the "side line organ"

The lateral lines connect the lateral sides from the medial plantar area of feet (1) all the way to the ears. They support the balance of posture between the frontal and dorsal side and between the right and left side of the body. They transmit between dorsal and ventral lines and the arm and spiral lines. They also act as "brakes" in lateral and rotation movements of the torso. (Myers, 2004, p. 121)



Ill. 16 Lateral line (Myers, 2004, p. 122)

Lesion, as a result of supination trauma, can in this way continue on to the cranium and the temporal bone where symptoms can arise. The line moves along the lateral lower leg compartment via the peroneal muscles (2) to the fibular caput (3), where the fibular collateral ligament (4) continues to the tibial lateral condyl (5) and connects up with the inferior tissue of the iliotibial tract (6), which holds the trochanter major of the femor in its fascial cup there while supporting the stability of the hip joint, forming a significant section. The pulling tension on the iliotibial tract is maintained from inferior by the lateral vastus of quadriceps muscle and from superior though the adductor muscles, tensor fascia latae muscle (7), medial gluteus muscle and the superficial tissue of the gluteus maximus muscle (8). They insert themselves as a communal complex extensively at the crista iliaca, from the anterior inferior spina iliaca (9) to the posterior superior spina iliaca (10), and form the connection to the torso. (Myers, 2004, p. 122-124)

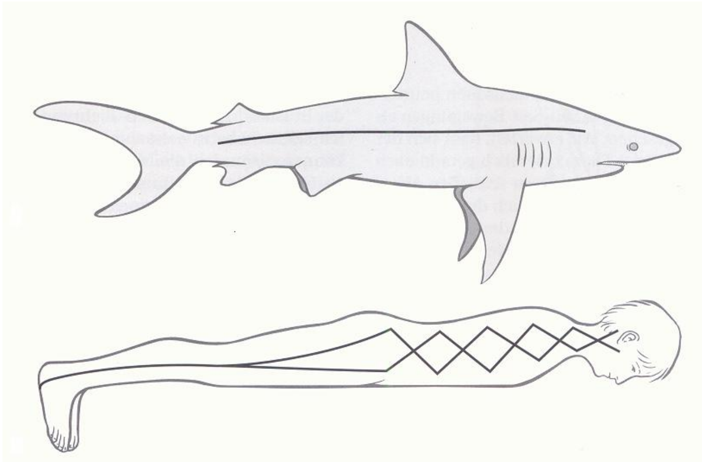
A pelvic obliquity leads invariably to variations in tension in the iliotibial tract and the adductor muscles which, on the one hand can lead to incorrect posture and compensation in the hips and knee joints. On the other hand the tension can be transmitted to the cranium via the “fascial basketwork”, formed by the abdominal obliquus externus muscle (11) and the abdominal obliquus internus muscle (12). This zigzag pattern continues in the rib area (13) through to the external intercostal muscles (14) and the internal intercostals muscles (15) to the first and second rib. (Myers, 2004, p. 124-126)

Myers (2004) argues that the perfect formation of the “X” in the lateral structures of the torso and neck are paramount for the regulation of the rotation movement performed during walking. These networks can be seen as partial spiral curves that are used as spring and buffer in order to balance out the complexity of walking. (Myers, 2004, p. 134)

The final “X” of the lateral line that streams into the area of the mastoid process (18) in the galea aponeurotica (18) is formed by the sternocleidomastoid muscle (16) on the outer side and the splenius capitis muscle (17) that forms the crus lying underneath. Major problems such as “Thoracic outlet syndrome” can be the result of an imbalance, through which direct irritation of the auditory system can occur. (Myers, 2004, p. 127)

In the depths, the lumbal quadratus muscle and the scaleni muscles and their associated fascia stabilise the lateral flexion. Apart from this a further “X” is to be found in the innermost layer of the neck. The tension of the anterior scalenus muscle that runs from the first rib in cranial posterior direction to the transverse process of the middle cervical spine creates a fascial continuum with the suboccipital muscles as well as the superior obliquus capitis muscle and the semispinalis capitis muscle. These muscles lead to a protraction of the occiput and hyperextension in the upper cervical spine. The scalenus muscle pulls the lower cervical segments in a flexion. Given an imbalance, the already disadvantageous posture of the head would be forced even further forward. (Myers, 2004, p. 131-132)

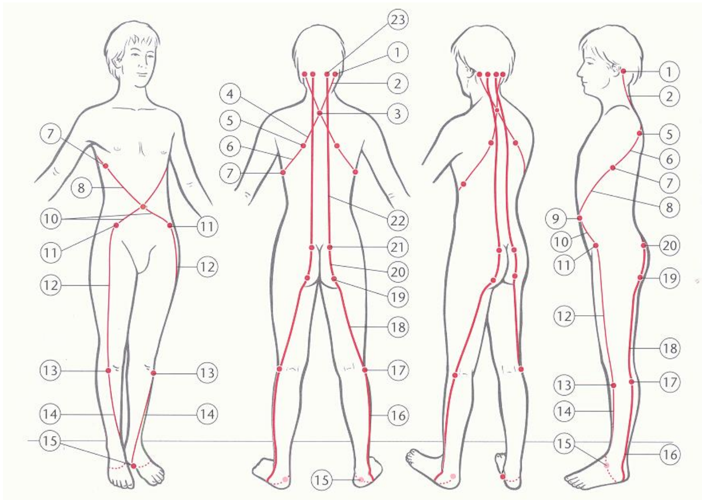
In a sense the lateral lines embrace the ear which is lined with highly developed vibration sensors (see chapter 3.4). These sensory organs of perception originally evolved from three parts of the fish body: the side line organ, the gill-slit and a joint of the jaw. (Ackermann, 2003, p. 70) Sharks can “hear” their prey wriggling with their so-called “side line organ”. It seems that only more highly developed vertebrates living on land had this vibration sensitivity at the upper end of the body, concentrated around the ear. One can assume that an influence exists because left-right abnormalities are more common in conjunction with problems of balance than with frontal and dorsal difficulties. (Myers, 2004, p. 132-133)



Ill. 17 Comparison of lateral line with the side line organ (vibration sensors along the lateral line) on fish (Myers, 2004, p. 133)

5.3.2.3 The spiral line

The spiral line wraps the body as a helix. This allows postural balance on all levels. The spiral line is involved in the emergence, compensation and fixation of twisting, rotation and lateral shifts that occur due to an imbalance.



Ill. 18 Spiral line (Myers, 2004, p. 138)

The spiral line starts at the asterion (1), moving forward into the splenius capitis muscle and splenius cervicis muscle (2) so that it touches the spinal processes from the sixth cervical vertebrae down to the fifth thoracal vertebrae (3). The mid-line is crossed over and continues in the major/minor rhomboid muscles (4) until the medial margin of the scapula (5). Here there is a direct fascial connection to the infraspinatus muscle. The spiral line continues in this strong fascial connection with the anterior serratus muscle (6) until the lateral area of the ribs

(7). The next section leads from the anterior serratus muscle to the external obliquus muscle (8) and continues in the aponeurosis of abdomen (9) through the linea albe and the internal obliquus muscle (10) to the superior anterior iliaca spina (11). Taking into consideration the many different mechanical line directions that depart from this point, the chances of the development of a lesion due to an imbalance between the spiral line, the lateral line and the deep frontal line are high. (Myers, 2004, p. 138-142)

The spiral line continues in the previously described lateral line in the lateral tensor fascia muscle and in the iliotibial tract (12) until the lateral area of the tibial condyl (13). From there the anterior tibial muscle (14) runs down to the base of the first metatarsal and the first cuneiform bone (15), where the long peroneal muscle inserts. Both muscles are joined by a fascia and form a loop under the tars arch of the foot. On the one hand an imbalance can cause massive, painful deformation of the foot and on the other hand provides a poor basis for the overall static, so ongoing compensation occurs all along the line. (Myers, 2004, p. 143)

The long peroneal muscle (16) continues laterally to the fibular caput (17) onto the femoral biceps muscle (18) until the tuber ischiadicum (19), further to the sacrotuberal ligament (20) and the sacrum (21). From there it continues upwards through the sacrolumbal fascia (22) and the spinal erector muscle (22) until the occiput (23). (Myers. 2004, p. 144-145)

A common pattern of posture reveals a shortening of the upper spiral line on one side of the body. The head is shifted to one side and slightly bent, the rib cage is displaced or rotated in the opposite direction, and the scapulae display varying positions. However the spiral line is seldom the cause of the posturally determined torsions and twists. It is much more concerned with compensating for deeper spinal rotations of other origins. (Myers, 2004, p. 149)

5.4 A model of an osteopathic treatment of tinnitus

Ratio (1999) introduced an overall osteopathic concept for the treatment of tinnitus in his lecture for the WSO.

Ratio (1999) explains that above all a reprogramming of the reticular formatio is the necessary basis for a change in the condition. The nucleus and axones of the reticular formatio function as a network in the brainstem from the medulla oblongata right through to the diencephalon. The reticular formatio transmits essential reflector stimuli, regulates vegetative functions, coordinates reflexes into patterns of movement and processes afferent stimuli in the sense of non-specific information for the cerebral cortex. (Duus, 1990, p. 193-196)

A reorientation of the afferences over the proprioceptors is necessary. This can occur through a correction of the talus position and decoaptation of both upper ankle joints. Furthermore, Ratio (1999) describes an energetic connection between the meniscus of the knee and the meniscus of the jaw joint. For this reason, the knee joints of tinnitus patients who have jaw problems and grind their teeth should be tested.

Furthermore a structural balance of the pelvis and examination of the muscular balance of the piriform muscle, lumbal quadratus muscle and psoas muscle are necessary. Apart from this the urogenital and intestinal area should like wise be checked.

L2 corresponds with the organ vertebra of the kidneys, although L2 should not be manipulated if the drainage is not functioning adequately. The correction of Th1 is advisable because of its energetic connection to the kidneys. In this very connection Ratio (1999) describes the kidneys as a reserve system. One can always manipulate Th1, even when the pulse is not strong enough (with regard to traditional Chinese Medicine). The function of the kidney is strengthened through this. Apart from this there is also an embryological connection to Th1 because the mesonephrus in stage 14 reaches the cervical segments. (Drews, 2006, p. 328)

Also, an examination of the cervicothoracic transition is significant because through a stasis problem by a compression of the subclavian vein and thoracal duct between clavicula and first rib, especially on the left, can arise, resulting in the tinnitus symptom. (Sammut et al., 2000, p. 240)

Ratio (1999) explains that a balance in the neurovegetative system should be an important factor in osteopathic treatment. In the case of most tinnitus patients one finds a compression in the segments C0/C1/C2. The reticular formatio receives a significant amount of information at the aperture of the subcranium. Normally one should wait one or two months before the next treatment in order to allow time for the self-healing process to begin.

In the case of a very rigid cervical spine one should also treat the liver viscerally. One commonly discovers an extension lesion on Th4 and derm algesia in the area of upper thoracal and cervical spine.

Cranial treatment consists, above all, of the balancing out of tension in the reciprocal membranes of the tentorium cerebelli with the falx cerebri, falx cerebelli and spinal dura mater in order to allow the fluctuation of the cerebrospinal liquor.

Possible fixations in the petrobasilar suture (connection to the SSB), the parietomastoid suture (in connection with the jaw joint), but also the petrosphenoidal suture (ligament of Grüber, Eustachian tube) should definitely be corrected.

It is advisable to check the jaw joint because a transmission of force follows via the periost of temporal bone from the aponeurosis of temporal muscle and masseter muscle inwards to the tentorium cerebelli and dura mater.

In conclusion the CV4 technique (IV. ventricle) is advisable. Through this technique one maintains a regulation of the longitudinal fluctuation of the cerebrospinal liquor. The liquor is washed from the centre to the periphery. Through this, the amplitude of the MRP is raised and also the exchange between the liquor and the cells of the central nervous system and the other body fluids. Furthermore the cranial membranes and fascia relax. The drainage of the venous sinuses improves. Consequently a regulation of important physiologic centres is achieved such as hypophysis (regulation of the hormone system), hypothalamus (centre of vegetative functions), grey nuclei, limbic system, cranial nerves, neurovegetative centre and medulla oblongata. (Arlot, 1998) With regard to tinnitus this technique has a positive effect on the auditory system and the accompanying symptoms of depression and anxiety.

Ratio (1999) argues however even if the “primary lesion” is treated it does not necessarily mean an end to the tinnitus symptom, because it is comparable with phantom pain. (Ratio, 1999)

6. Methodology

The purpose of this study is to analyse and discuss general osteopathic treatment given to a defined selection of patients, with subsequent evaluation of the results. The question then posed is whether general osteopathic treatment can change the tinnitus symptom in its perceived sound volume, pitch, discomfort and character.

6.1. Selection criteria

This study is based on 44 patients suffering from tinnitus. It was made sure that all patients had been medically diagnosed and had received treatment. Patients from open practices (ENT and general practice), tinnitus self-help groups, ENT department of the hospitals Barmherzige Schwestern and General Hospital in Linz as well as patients from psychotherapy were represented in this study.

6.1.1 Osteopathic group

The treatment group (23 tinnitus patients) received general osteopathic treatment. It was investigated whether the tinnitus symptom could be directly influenced in its sound volume, pitch, discomfort and character. Children and adolescents up to the age of consent were treated under a parental supervision.

6.1.2 Control group

The control group (21 tinnitus patients) received instructions for Jacobson's progressive muscle relaxation, whereby it was investigated whether the tinnitus symptom can be changed in its sound volume, pitch, discomfort and character by relaxation alone. This relaxation technique was developed by the American doctor and psychophysiologist Edmund Jacobson (1885 – 1976). In his practice he noticed a close connection between mental strain and tenseness of the muscles. Conversely he noticed that myogelosis can be reduced by specific flexing and relaxing of various muscle groups, whereby the mental condition improves. The progressive muscle relaxation according to Jacobson has positive effects on general well-being, the immune system, the cardiovascular system and the inner organs. Additionally it has a pain-relieving effect and stabilises the mental condition. (Hainbuch, 2004, p. 13-14)

The data of the osteopathic group was compared to that of the control group which received instructions for Jacobson's progressive muscle relaxation to find out whether the relaxation effect alone of the patient through specific muscle relaxation exercises performed in a quiet atmosphere can affect the tinnitus symptom in its intensity, pitch, discomfort and character.

The patients in the control group also received general osteopathic treatment on ethical grounds after the data had been collated.

6.2 Exclusion criteria

Patients suffering from tinnitus due to pathological reasons – otitis media, otosclerosis, tubal- and middle ear catarrh, acoustic nerve neurinoma, morbus ménière, intracranial increase of pressure (by space-taking processes such as craniocerebral trauma), aneurysm, angioma, ototoxic damage – were excluded from the study. An individual contra-indication diagnosed during osteopathic treatment or patients not keeping appointments were likewise grounds for exclusion.

6.3 Data collection

Sound volume, pitch, discomfort and character of the tinnitus are the subject of evaluation.

To record the anamnesis, establish results and document the course of treatment an **osteopathic examination form** covering the cranial, visceral, myofascial and psychosomatic system was compiled especially for the study. The above-mentioned osteopathic models and approaches of leading osteopaths (see chapter 5) served merely as guidelines, however, and each tinnitus patient was tested and treated individually.

Before the first treatment (osteopathic group) and the instructions for Jacobson's progressive muscle relaxation (control group) the osteopath filled in an osteopathic examination form to find out if there was a contra-indication such as an underlying disease (e.g. diseases of the cardiovascular system, kidneys, diabetes mellitus et al.) or secondary symptoms (depression, psychosis, anxiety, sleeping disorders et al.), which might influence the course of treatment.

The results of the general osteopathic treatment, the data of the course of treatment and reactions were recorded either during or immediately after each general osteopathic treatment by the osteopath.

Osteopathic examination

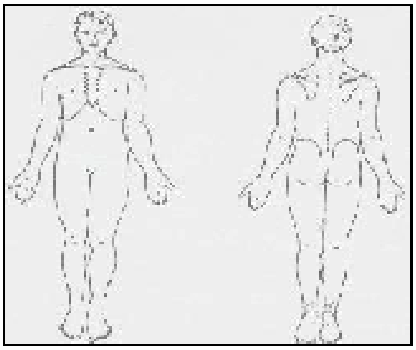
Name: ____________________ Age: ______ Date: ______

Address: ____________________ Telephone: ____________

Occupation: ____________

Complaint(s): acute chronic

structural



Cause? Trigger?
How long? First time/repeated?
Pain Where? Radiation?
How? Quality?
When? Day/night?
Worse because of?
Better because of?
Medicine: ____________
Current therapy: ____________

Operation/implants: ____________
Diseases (antibiotics): ____________
Trauma/accidents: ____________

General situation: tired/fit
Sleep: recovery/sleep disorder/insomnia
Daily life:
Diet: smoker since:

psychosomatic

Allergy: ____________
Immunisation: ____________
Osteoporosis: ____________
Haemophile: ____________
Diabetes: ____________

Digestion:
Ingestion: oesophagus:
stomach:
liver:
gall bladder:
intestine:
Elimination: colon:
kidney:
bladder:

Respiration: pulmonary:
Circulation: heart/blood:
blood pressure:
Gynaecology: uterus/ovaries:
birth control pill/loop:
pregnancy:
prostate:

visceral

ENT: thyroid gland

cranial

Cranium:
Headache:

eyes
jaw

Medical examination:
Laboratory: ____________
Radiography: ____________
MRI: ____________
Other:

General osteopathic treatment

No.	Date	Reaction	Therapy
1			
2			
3			

Comment:

To establish the subjective perception of the noise in the ear all patients filled in questionnaire 1 before they received the first treatment (osteopathic group) or the instructions for progressive muscle relaxation according to Jacobson (control group); immediately after the first treatment or the muscle relaxation they filled in questionnaire 2. Each time a single visual analogue scale (VAS) was included to make comparison with prior data impossible.

An objective data collation regarding the intensity of the tinnitus was carried out immediately prior to the first treatment (osteopathic group) and the instructions for progressive muscle relaxation according to Jacobson (control group) and immediately after the first treatment and the instructions for progressive muscle relaxation. Audiometry was used to find out about dB and Hz.

In keeping with the concept of osteopathy, the principle of activating self-healing, all patients (osteopathic and control group) were interviewed with the help of an evaluation form after three treatments in six weeks. To assess the long-term development of the tinnitus the data of questionnaire 1 is compared to that of the evaluation form.

6.3.1 Measurement of the tinnitus parameters

In order to evaluate any changes in the tinnitus the data regarding intensity, discomfort, pitch and character are compared. To gain standardised data in the treatment of tinnitus only the mean value of the perceived sounds (e.g. on both sides, on both sides and in the head) is taken into account for the evaluation of the data.

On the one hand the volume of the tinnitus is determined by carrying out a psycho-acoustic comparative measurement of the tinnitus intensity in dB with an audiometer and on the other hand by using the subjective marks on the visual analogue scale in the questionnaires 1 and 2, plus the information given on the evaluation form.

Also the pitch (high/low) of the tinnitus sound is determined by carrying out a psycho-acoustic comparative measurement of the tinnitus intensity in Hz with an audiometer and by using the subjective marks on the visual analogue scale in the questionnaires 1, 2 and the information given on the evaluation form.

The discomfort experienced by the tinnitus patient is determined solely by the subjective marks on the visual analogue scale on questionnaires 1 and 2 and the information given on the evaluation form. This data show primarily the mental strain caused by the noises/tone in the ear in everyday life and is used to determine the degree of severity.

The character of the tinnitus is also determined solely by the subjective information on questionnaires 1 and 2 and the evaluation form.

On the one hand we aim to establish whether general osteopathic treatment (osteopathic group) or progressive muscle relaxation according to Jacobson (control group) can cause an immediate change in the tinnitus. On the other hand final evaluation with the help of the evaluation forms after six weeks should indicate any long-term changes to the tinnitus.

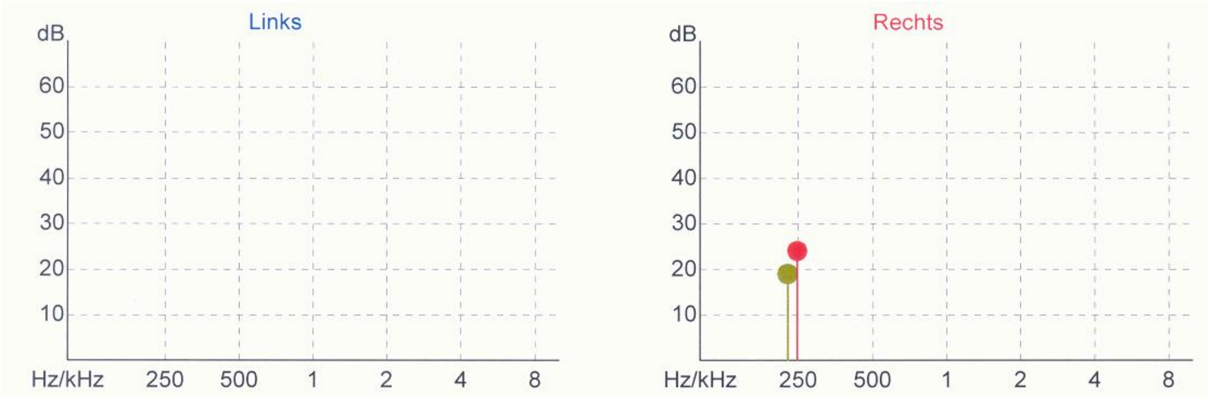
6.3.2 Measurement of the tinnitus intensity (TIM)

To analyse tinnitus a tinnitus intensity measuring procedure is carried out. Different frequencies are offered by a generator whereby the patient decides which of these signals comes closest to the sound of his/her tinnitus. (Feldmann, 1998, p. 53)

Frequently higher decibels have to be offered when determining the intensity of the tinnitus because often the hearing is impaired in exactly this frequency range. For the masking in dB the intensity is increased until the patient no longer hears his/her tinnitus, only the generated tone or noise.

The measurement of the tinnitus intensity is a standardised method in ENT medicine, whereby a decibel value of the tinnitus is measured which can be relatively easily reproduced. The advantage of this method is that we measure in the same sensory modality as the disorder. This is a disadvantage at the same time because there is often a hearing impairment in the same frequency range as the tinnitus. The measurement of the tinnitus intensity as a psycho-acoustic measurement is the best way of describing the volume of the tinnitus in dB and is regarded as the most objective.

Using the intensity measurement we additionally attempt to determine the pitch (high/low) of the tinnitus tone by determining the main frequency in hertz (matching).



Ill. 19 Measurement of tinnitus intensity before (red) and after (green) treatment/relaxation technique (HTTS – hearing test programme)

Illustration 18 shows the measurement of tinnitus intensity in the case of a patient with tinnitus in the right ear. The measured value in red shows the perception before the treatment/ instruction for the progressive muscle relaxation according to Jacobson. When looking at the second measured value (in green) after the treatment/relaxation technique we can notice a change of intensity in dB and a change of pitch in Hz, respectively.

We have to bear in mind, however, that even this "objective" high-tech method contains the process of subjective perception – precisely in the disturbed modality.

6.3.3 The Visual Analogue Scale (VAS)

The evaluation of the subjective severity is more effective with psychometric methods, such as the standardised questionnaires and visual analogue scales. These methods are good for evaluating therapy effects, monitoring the therapy process and assessing the spontaneous fluctuation range of tinnitus. The visual analogue scale is easily implemented and thus it is a practicable instrument that supports tinnitus intensity measurement. Furthermore it is an instrument that patients can use to monitor and evaluate tinnitus themselves. (Goebel, 2001, p. 25)

On the visual analogue scale (see questionnaire 1, 2 and evaluation form) the subjective loudness and discomfort of tinnitus are evaluated respectively on a scale of one hundred millimetres. (Goebel, 2001, p. 155) The left end of the scale is fixed at zero (no noise or discomfort) and the right end of the scale is fixed at one hundred (extreme intensity or extreme discomfort). The patient uses an orthogonal mark on each scale for the current intensity of tinnitus loudness or discomfort. Afterwards the distance marked in millimetres (without decimal places) is measured with a millimetre ruler. This value corresponds to numerical data in per cent of loudness or discomfort. Patients mark only one visual analogue scale at a time, so they cannot be influenced by scales used previously.

This study uses a visual analogue scale of one hundred millimetres, which is then turned to a vertical scale, in an attempt to evaluate the subjective perception of tinnitus pitch. For the visual comparison of tinnitus pitch, a mark on the bottom of scale (trough, from zero) indicates very deep tones such as humming or buzzing, a mark at the top of scale (up to a hundred) denotes extremely high tones such as whistling.

6.3.4 The Tinnitus Questionnaire

This study uses specifically designed tinnitus questionnaires, particularly in respect of tinnitus penetration, based on the tinnitus questionnaire developed by Goebel and Hiller in 1992, including the visual analogue scale for grading tinnitus severity and for the evaluation of data. (Goebel, 2001, p. 199-200)

Tinnitus questionnaire 1 evaluates on the one hand general data (age, sex, trigger of tinnitus, negative influences) prior to general osteopathic treatment (osteopathic group) or before the instructions for progressive muscle relaxation according to Jacobson (control group) and on the other hand the comparison data of loudness, pitch, discomfort and character of the ear noise/tone.

Tinnitus questionnaire 2 evaluates the comparison data of loudness, pitch, discomfort and character of tinnitus after the first osteopathic treatment (osteopathic group) or after the instructions for progressive muscle relaxation according to Jacobson (control group).

The evaluation form evaluates the data of loudness, pitch, discomfort and character of tinnitus after three osteopathic sessions, six weeks after the first evaluation using questionnaire 1. To assess the long-term development of tinnitus the data from questionnaire 1 is compared to that of the evaluation form. In this assessment all patients are included, also the control group patients who likewise received osteopathic treatment after the measuring and questioning using questionnaire 1 and 2.

Tinnitus Questionnaire 1

Patient no.: ☐

Age: ☐

male ☐ female ☐

1) **How long have you been suffering from tinnitus?** ☐

2) **Where do you notice the ear noise?**

right ear: ☐

left ear: ☐

on both sides: ☐

in the head: ☐

3) **Where do you think the tinnitus comes from?**

spontaneous without event	☐	disorders of teeth or jaw	☐
excessive noise exposure	☐	stress	☐
whiplash injury	☐	particular event	☐
irregular movement	☐	emotional strain	☐
irregular posture	☐	other:	________

4) **When do you mostly notice the noise?**

in silence ☐	at work ☐	time of day: ________
outdoors ☐	permanently ☐	

5) **Does the tinnitus change through:**

stress	☐	emotional strain	☐
certain head position(s)	☐	psychological stress	☐
physical exertion	☐	excitement	☐
certain food and drinks	☐	other factors:	________

6) **In which intensity do you notice the tinnitus?**
Please use a vertical line to mark the intensity of your tinnitus on the scale between 0 (no tinnitus) and 100 (extremely loud)

right ear: 0 — 100
no tinnitus — extremely loud

left ear: 0 — 100
no tinnitus — extremely loud

head: 0 — 100
no tinnitus — extremely loud

7) **How annoying/uncomfortable/unpleasant is the noise now?**
Please use a vertical line to mark the scale between 0 (not at all) and 100 (extreme discomfort)

0 — 100
not at all — extreme discomfort

8) **How would you describe the pitch of the tinnitus?**
Please use a horizontal line to mark the pitch of your tinnitus on the line between deep and high.

right ear: high — deep

left ear: high — deep

head: high — deep

9) **How would you describe the character of your tinnitus?**

whistling	☐	humming	☐	hissing	☐
ringing	☐	sawing	☐	cracking	☐
swishing	☐	roaring	☐	droning	☐
rushing	☐	other:	______		

10) **How would you describe the pattern of your tinnitus?**

steadily monotone	☐
intermittent	☐
pulsating	☐
rising and falling	☐
other:	______

11) **Have you experienced other symptoms since the tinnitus began?**

over-sensitivity to loud sound	☐
loss of hearing	☐
vertigo/dizziness	☐
others:	______

Thank you for your assistance!

Tinnitus Questionnaire 2

Patient no.: ____

1) **Can you hear the noise/tone now?**

yes ☐ no ☐

2) **Where do you notice the ear noise?**

right ear: ☐

left ear: ☐

on both sides: ☐

in the head: ☐

3) **How would you describe the character of your tinnitus?**

whistling	☐	humming	☐	hissing	☐
ringing	☐	sawing	☐	cracking	☐
swishing	☐	roaring	☐	droning	☐
rushing	☐	other:	____________		

4) **How would you describe the pattern of your tinnitus?**

steadily monotone ☐

intermittent ☐

pulsating ☐

rising and falling ☐

other: ____________

5) **Have you experienced other symptoms since the tinnitus began?**

over-sensitivity to loud sound ☐

loss of hearing ☐

vertigo/dizziness ☐

others: ____________

6) **In which intensity do you notice the tinnitus?**
Please use a vertical line to mark the intensity of your tinnitus on the scale between 0 (no tinnitus) and 100 (extremely loud)

right ear: 0 — 100
no tinnitus

left ear: 0 — 100
no tinnitus

head: 0 — 100
no tinnitus

7) **How annoying/uncomfortable/unpleasant is the noise now?**
Please use a vertical line to mark the scale between 0 (not at all) and 100 (extreme discomfort)

0 — 100
not at all

8) **How would you describe the pitch of the tinnitus?**
Please use a horizontal line to mark the pitch of your tinnitus on the line between deep and high.

right ear: high — deep

left ear: high — deep

head: high — deep

Tinnitus Questionnaire 2

Patient no.: ☐

1) **Can you hear the noise/tone now?**

yes ☐ no ☐

2) **Where do you notice the ear noise?**

right ear: ☐

left ear: ☐

on both sides: ☐

in the head: ☐

3) **How would you describe the character of your tinnitus?**

whistling	☐	humming	☐	hissing	☐
ringing	☐	sawing	☐	cracking	☐
swishing	☐	roaring	☐	droning	☐
rushing	☐	other:	________		

4) **How would you describe the pattern of your tinnitus?**

steadily monotone ☐

intermittent ☐

pulsating ☐

rising and falling ☐

other: ________

5) **Have you experienced other symptoms since the tinnitus began?**

over-sensitivity to loud sound ☐

loss of hearing ☐

vertigo/dizziness ☐

others: ________

6) **In which intensity do you notice the tinnitus?**
Please use a vertical line to mark the intensity of your tinnitus on the scale between 0 (no tinnitus) and 100 (extremely loud)

right ear: 0 — 100
no tinnitus

left ear: 0 — 100
no tinnitus

head: 0 — 100
no tinnitus

7) **How annoying/uncomfortable/unpleasant is the noise now?**
Please use a vertical line to mark the scale between 0 (not at all) and 100 (extreme discomfort)

0 — 100
not at all

8) **How would you describe the pitch of the tinnitus?**
Please use a horizontal line to mark the pitch of your tinnitus on the line between deep and high.

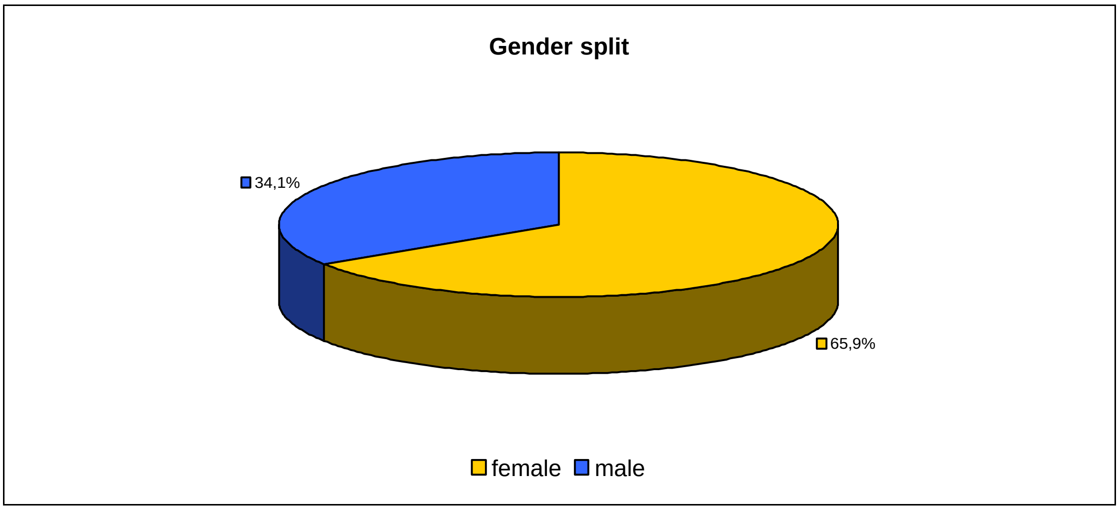
right ear: high — deep

left ear: high — deep

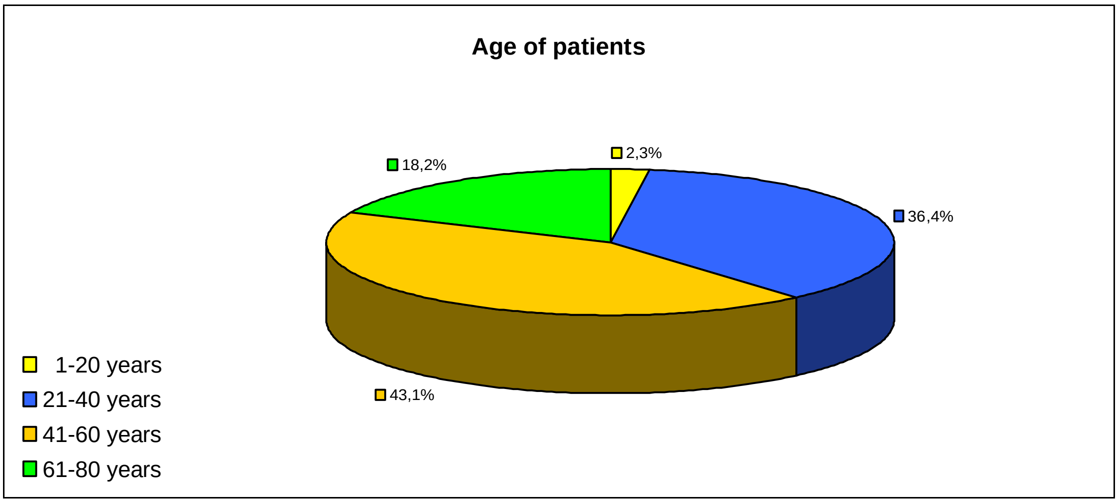
head: high — deep

7. Explanation of the statistical analysis

The data from questionnaire 1 completed by all patients (osteopathic group and control group together) regarding sex, age, stage, local perception, severity, triggering and changing factors, character, process and additional problems result in the following evaluations:



Two thirds of the persons involved in the study were women, one third men. From this fact however, one cannot conclude that in principle more women than men are affected by tinnitus, because according to the German ENT Congress (2003) men and women are affected on relatively equal terms (see chapter 2.5).

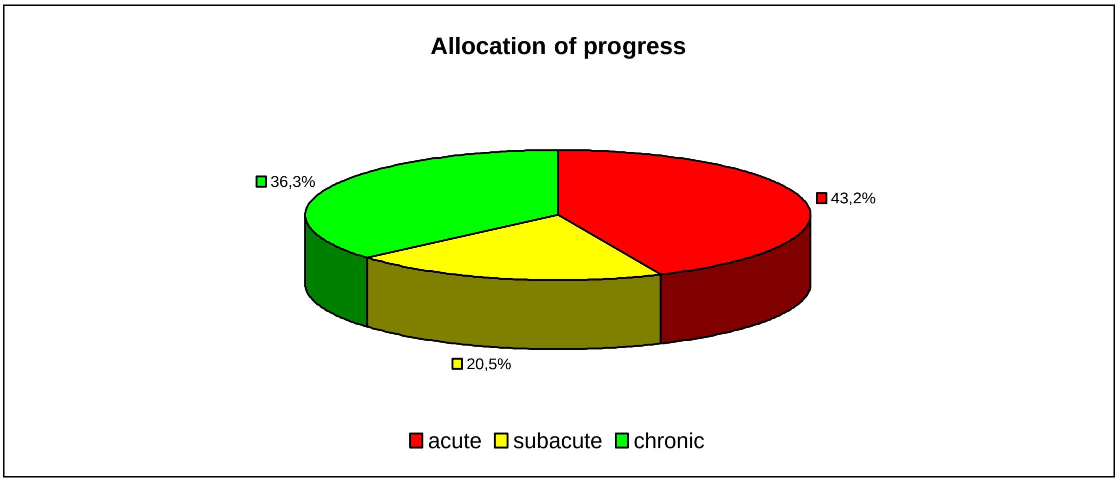


This model shows that the patients between 40 and 60 years of age are most affected by tinnitus, followed by the group of people aged between 21 and 40. One could assume that in particular people who have demanding, performance-oriented careers, are affected by tinnitus through overworking or stress.

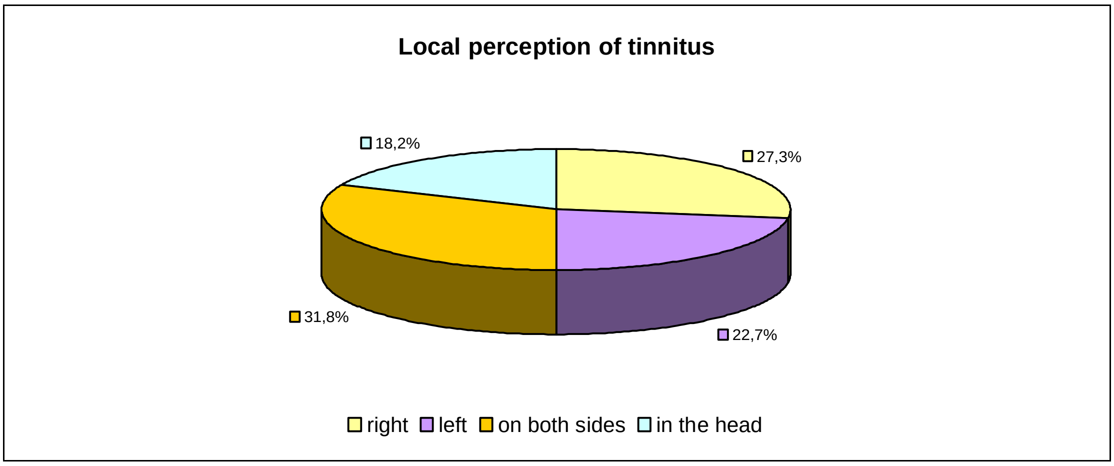
In comparing males and females it was found that the problems of tinnitus generally affect women of about 50 years, and men about 60 years. Traditional Chinese medicine could give us an explanation for this, as it describes one kind of tinnitus in particular with exhaustion conditions. During the menopause a gradual exhaustion (“emptying”) of kidney Yin results from asset erosion, whereby the exceeding Yang energy of the wood element (gall “fullness”) can ascend. This imbalance (Yin cannot hold Yang) is shown in the form of ascending flushes, profuse sweating, headache and, in extreme cases also tinnitus, as a high, loud whistling. (Diolosa, 2004)

It is interesting to note that the 8 patients over 61 years who were examined in the study suffer from chronic tinnitus (up to 15 years), which means that the trigger moment also lies in the most affected group of people between 41 and 60 years.

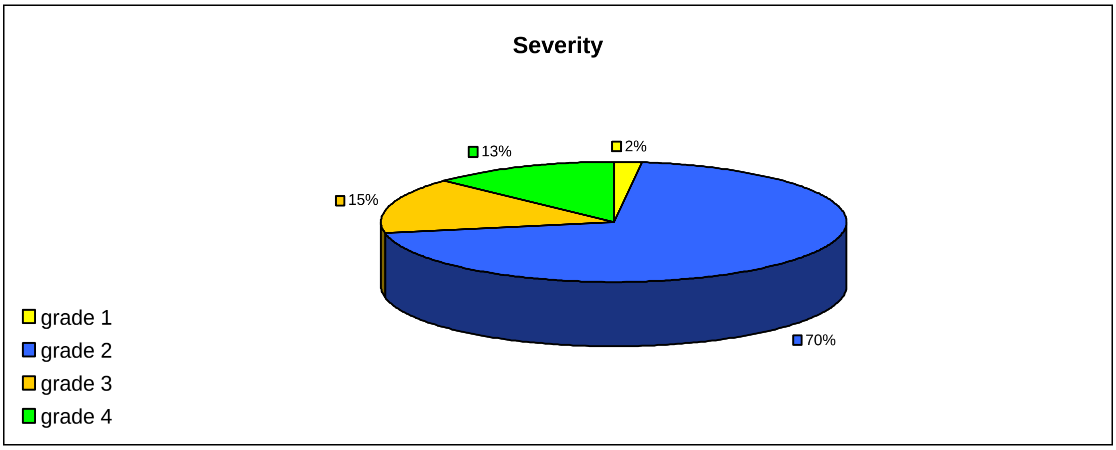
The youngest patient suffering from tinnitus is a child of 11 years. However, according to the anamnesis, this child suffers from the fear of being left alone and panic attacks due to his parents’ separation.



A comparison of the data between the acute, subacute and chronic group of patients can be made by analysing the duration. In this study 19 patients suffering from acute tinnitus (10 patients in osteopathic group/9 patients in control group), 9 patients in the subacute stage (5 patients in osteopathic group/4 patients in control group) and 16 patients suffering from chronic tinnitus (8 patients in osteopathic group/8 patients in control group) were examined.



The reporting of the local perception of tinnitus shows a relatively even distribution between right, left and both sides. The number of patients (8) who perceive the tinnitus inside their head, mostly in the area of the lamdoid suture or on their calvaria, is somewhat smaller.



The determination of the severity shows that 70% of the patients suffer from second-grade compensated tinnitus. The patients indicate that the tinnitus mainly appears in silent situations, mostly in the evening and at night. The tinnitus is already noticed when the external noise level is low, although it can be masked by natural noises or ambient noise. Stress and psychological/physical burdens can disturb or aggravate it.

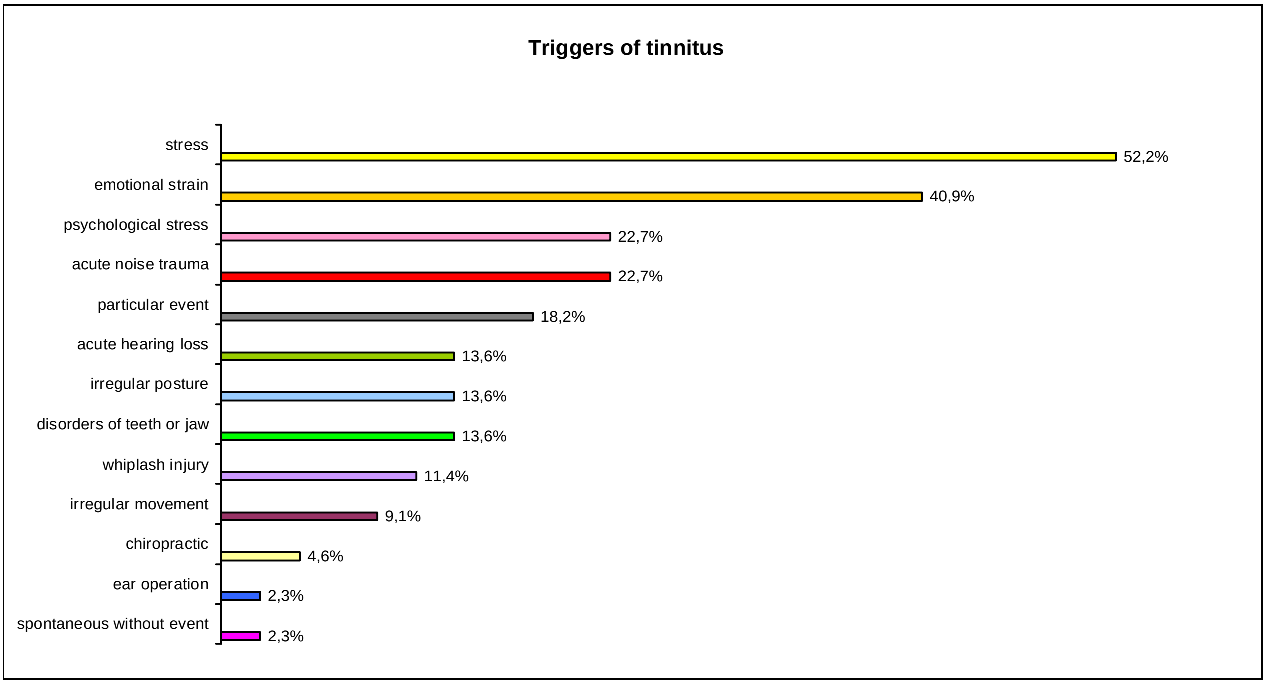
The next group consisting of 15% of the patients already shows a decompensated tinnitus of the third grade. The patients complain that the tinnitus leads to constant restrictions in private and professional situations. The ringing in the ears is hardly masked any more by natural noises or noises from the surroundings. The patient already shows signs of secondary symptomatology such as weak concentration or sleep disorders.

The most seriously affected group (13%) is that of people suffering from decompensated tinnitus of the fourth grade. The study shows that above all, patients suffering from acute tinnitus who cannot cope with this sudden situation are affected. The permanently disturbing tinnitus, independent of the level of the external noise, leads to complete decompensation in private life. The tinnitus influences the entire sensory perception and orientation. The patient suffers substantially from insomnia, weak concentration, anxiety neurosis and there is severe psychological stress. The quality of life is considerably disturbed. Anamnesis confirms that the patients suffer from substantial depression and avoid contact with other people.

Only 2% (1 patient) suffer from first-grade tinnitus. The patient states that he notices the tinnitus only in quiet environments and silence. He notes the noise/tone, but is able to suppress it and keep it in the background. Additionally the value indicated for the visual analogous scale was “0”, which makes one assume that there is no psychological stress. This patient says, however, that he has already lived with tinnitus for 20 years and has come to terms with it.

This confirms Goebel’s statement (2001) that there is a significant correlation between the duration of the tinnitus and the weighting of the problems resulting from it. Patients with chronic tinnitus who have already lived with this symptom specify a lower strain factor than the patients suffering from acute tinnitus. (Geobel, 2001, p. 40)

The tinnitus symptom is comparable to pain. In addition, in most cases tinnitus can be seen as a warning sign, telling us that we have taken on too much, both physically and mentally. The attention should thus not be centred on the tinnitus symptom, but on the reasons for the behind the triggers of tinnitus. (cf. AWMF online).



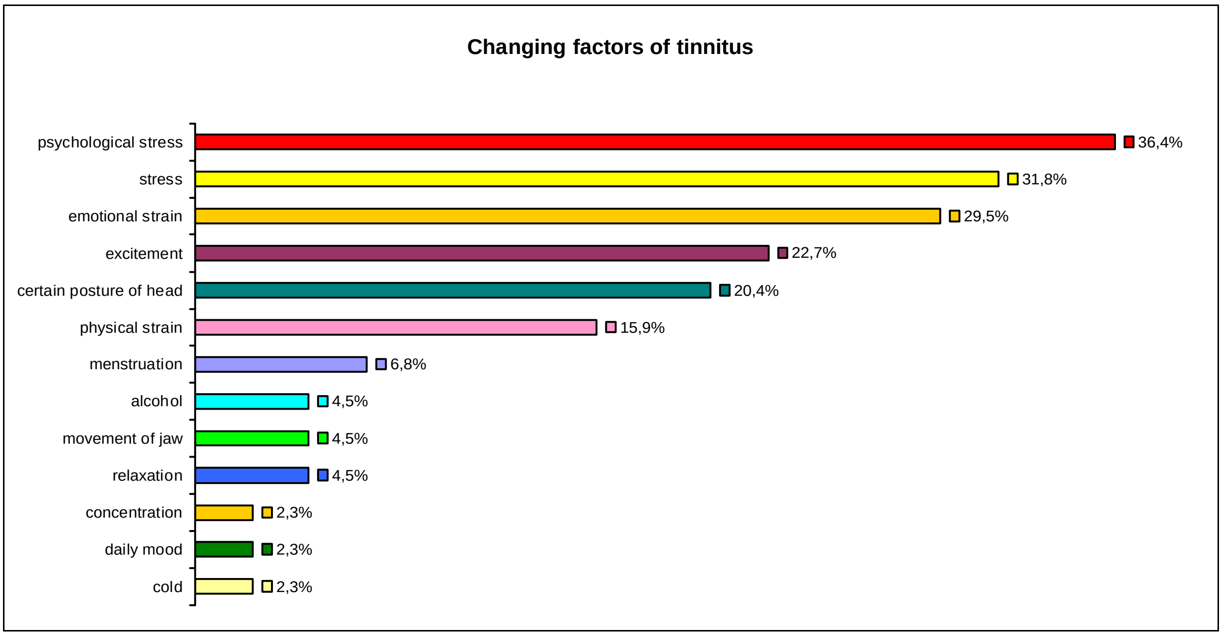
If one evaluates the triggering factors for the ear noise, four groups emerge:

The data concerning the trigger factor for the ear noise shows that above all, it is stress (52.2%) and emotional strain (40.9%) that are most important. However, it has to be mentioned that most patients named several factors. Very often, stress, emotional strain, a particular event (often mental shocks) (18.2%) and psychological strain (22.7%) are combined.

In respect of acute noise trauma (22.7%), extreme stress, such as explosions, shots or a visit to a disco, were named most often. Unfortunately, the organ of Corti is hurt directly when noise trauma happens to somebody, because sensitive sensory hair cells break off – something which is irreversible once it has happened. This, and sometimes ear surgery (inner ear implants) can also lead to spontaneous actions and incorrect processing (see chapter 3.4.2). Information given by this group shows that osteopathic treatment seldom leads to success.

Acute hearing loss (13.6%) is quite often also a trigger moment for tinnitus. With a majority of these patients no direct cause can be found. One assumes that the reasons for this lie in disturbances of micro circulation in the small inner ear vessels. Although hearing often recovers within a short time, the tinnitus remains. According to Goebel (2001), in these cases vasoactive infusion therapy has a success rate of up to 60%. (Goebel, 2001, p. 29)

The fourth group: “Disorders of teeth and jaw (13.6%), whiplash injury (11.4%), irregular posture (13.6%) and irregular movement (9.1%) ”, shows structural changes or degenerations in joining and myofascial structures, very frequently followed by problems with circulation and/or a congestion problem of the venous blood circulation. The data of two patients, who name specifically chiropractic treatment of the cervical spine as the trigger of their tinnitus, is of particular medical concern.



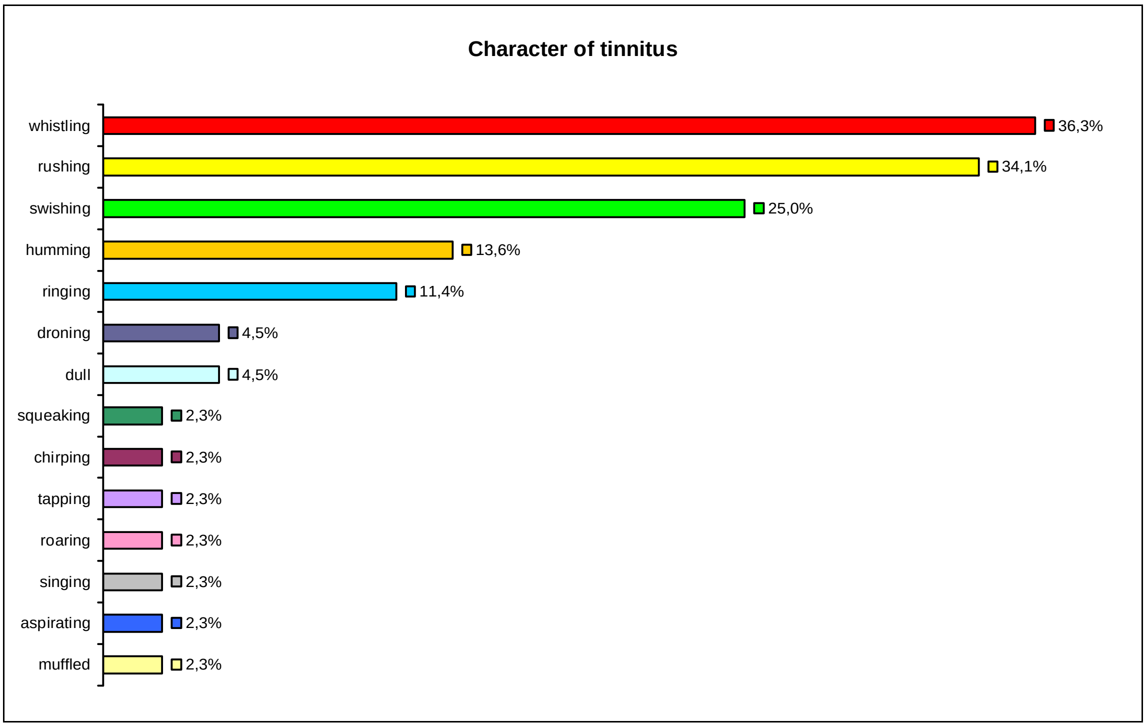
This breakdown shows which factors mainly intensify the subjective perception of tinnitus.

Psychic factors such as “psychological strain”, “stress”, “emotional strain”, “excitement” and “mood on the day” are the most influential, even with patients who initially named a structural event as the cause.

It is also important to note that tinnitus can be affected by movements of the cervical spine and by certain positions of the head. “Physical strain/overstrain” and “concentration” may also intensify tinnitus as they cause an increase in pressure. A patient suffering from chronic tinnitus indicated “a cold” as reinforcing, three patients “menstruation”, which could be

interpreted as a lack of blood (according to traditional Chinese medicine), and/or that the pituitary gland**,** which is included in the functional unity of SSB**,** is irritated.
Only two patients (in the chronic stage) mentioned “alcohol” and “relaxation” as short-term (from several hours up to one day) relief.

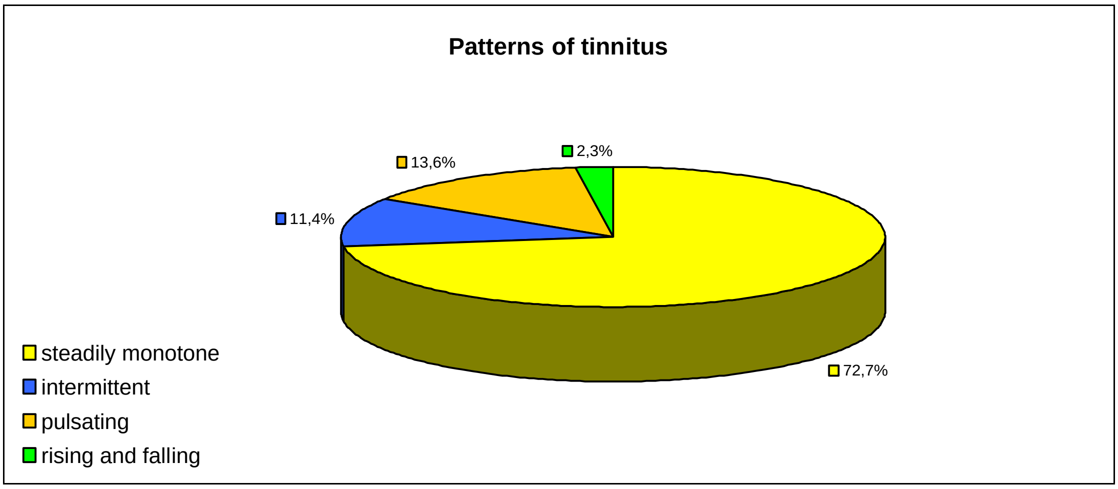
In most cases tinnitus is experienced quieter and less disturbing during the day, which indicates cover from natural noise or from background noise. In most cases tinnitus is perceived in the evening or at night. It often occurs as patients fall asleep, when the other perception of senses is reduced. Tinnitus then acts like an incessant alarm call which delays falling asleep or even prevents doing so.



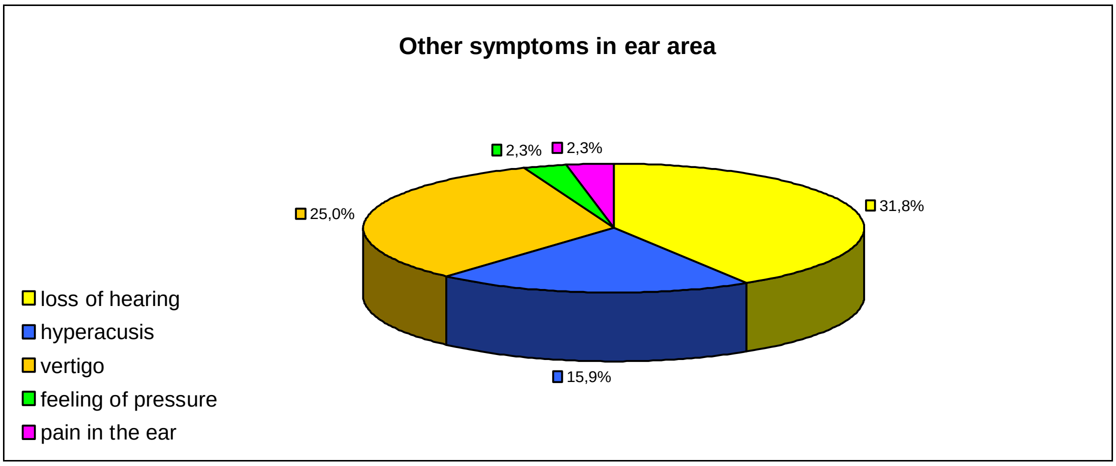
The character of tinnitus shows very varying qualities, with the patients often indicating several qualities. A whistling, rushing and swishing character is most common.

Compared to the visual analogue scale regarding the pitch of the tone, the characters can be assigned to high/middle/deep tones or noises. According to the data given by the patients a whistling, rushing, swishing, ringing, squeaking and chirping character forms a high tone. In the middle range a quality such as rushing, singing, roaring and swishing was named. Deep tones form a humming, droning, tapping, swishing, rushing, muffled perception. The character of aspirating or rushing was indicated as sheer noise, as in putting an empty shell to your ear and listen.

Anamnesis shows that 14 patients suffer from “high blood pressure”, and/or “blood pressure fluctuations”, which could probably represent one of the causal problems. In judging the character and the pitch of tinnitus it was found out that these patients show a strong tendency towards higher pitched characters of tinnitus.



Two thirds of the patients (32 patients) indicated a steadily monotonous tone, 7 patients a pulsating character. 5 patients indicated that sometimes the tinnitus disappears for a short time, but quickly returns again. Only one patient indicated a rising and falling patterns.



14 people suffering from tinnitus specified a considerable loss of hearing which is medical proven. Epidemiological data point to that the incidence and prevalence of tinnitus increase

parallel to the rise of the loss of hearing. Most patients concerned suffer from a proven inner ear loss of hearing. (Goebel, 2001, p. 18)

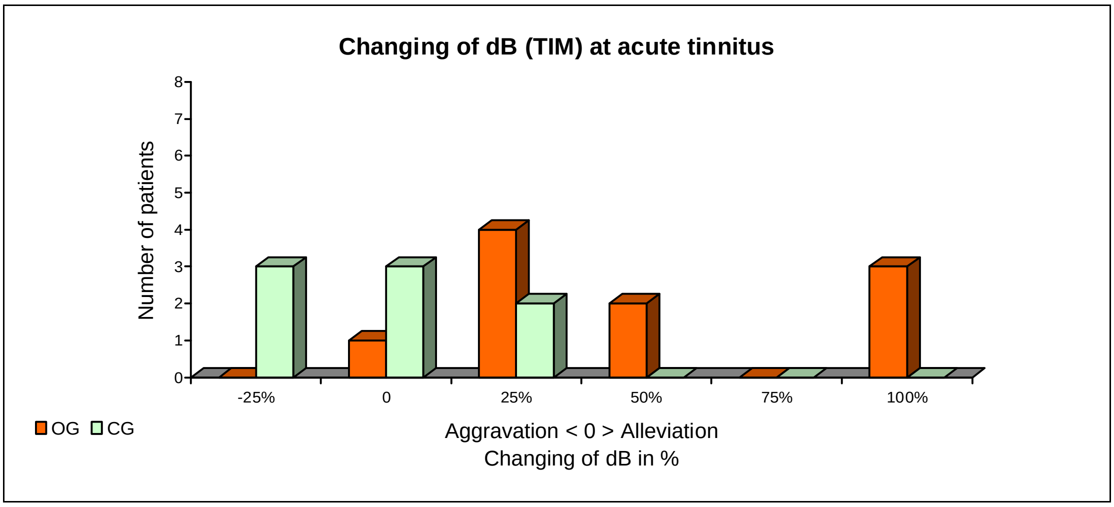
In this study 7 patients (15.9%) indicated a definite “hyperacusis”. One patient suffers from “ear pain” without any medical reason.

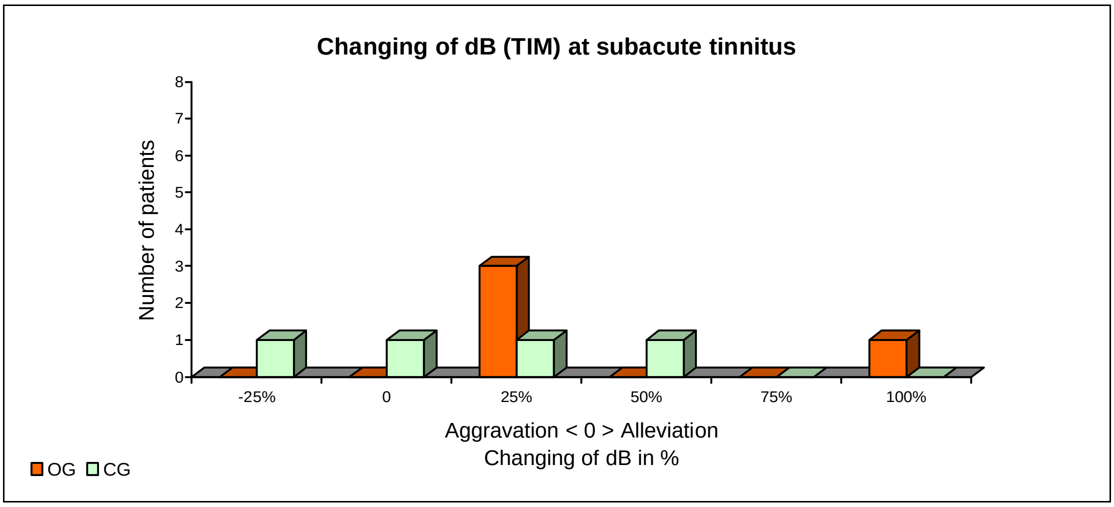
According to Goebel (2001) about 40 to 56% of all people suffering from tinnitus complain of hyperacusis. An incorrect processing of the central neuronal network or a traumatic dysfunction of the outer hair cells is suspected. One distinguishes between peripheral hyperacusis with abnormal patterns in distorsion products of otoacoustic emissiones and central hyperacusis with intensifying tinnitus for hours after low sound influences. In extreme cases even normal noises lead to major vegetative complaints sometimes as severe as attacks of panic (phonophobia). (Goebel, 2001, p. 86) At the German ENT Congress (2003) it was again confirmed that 44% of the patients, particularly those who suffer from chronic tinnitus, suffer from hyperacusis at the same time. (Maier et al., 2003)

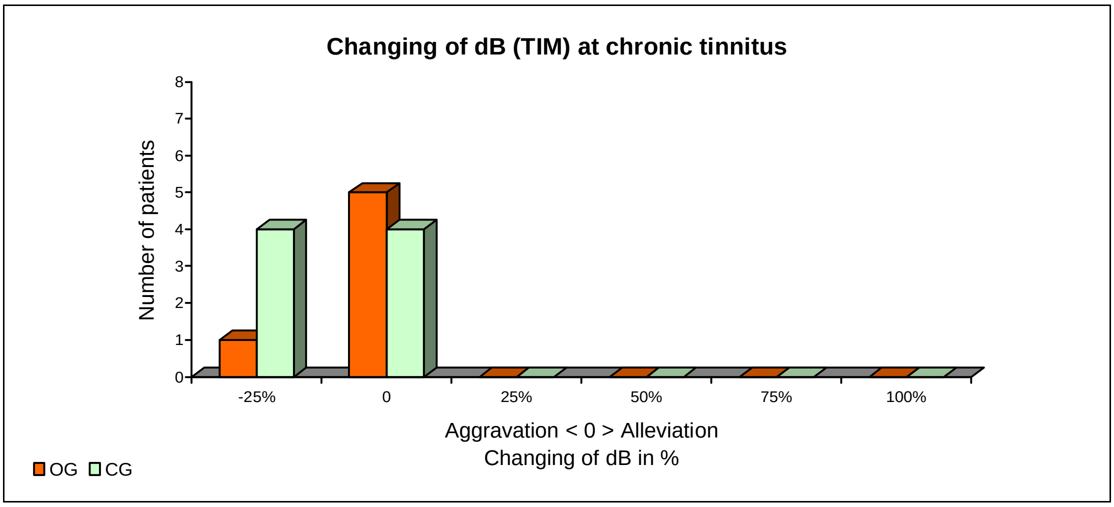
11 patients indicated that they additionally suffer substantially from dizziness. Vertigo is often accompanied by tinnitus. One of the most frequent causes is a rise of the craniocervical tension and from it resulting rotation lesion of temporal, often released by muscular dysbalance with incorrect posture or by trauma. This results in the semicircular arcs of the organs of equilibrium of each side not being aligned correctly with each other, disturbing the fine coordination which makes the central nervous system contain confusing messages. (Nusselein, 2000)

Anatomically, the cochlea as a basis for linguistic communication and hearing and the labyrinth as basis for physical action and equilibrium are not separated, because sacculus and utriculus are connected by a ductus reuniens with the cochlea, so that there is a mutual fluid space filled with viscous endolymph. The aqueous perilymph, which surrounds the endolymphatic space, serves as a buffer of the entire membranous labyrinth. Particularly the subdural blindly ending endolymphatic sac appears to be a storage reservoir and makes a buffering of pressure fluctuations possible, where it is exposed to the pressure of liquor. The perilymph is drained over the perilymphatic duct in the subarachnoidal space. The assumption arises that unphysiological dural tensions can definitely result in tinnitus together with vertigo. (Dräger, 2006, p. 18)

Measurements of tinnitus intensity (TIM) in decibel in comparison between osteopathic group (OG) and control group (CG)







The measurements of intensity of tinnitus are for the evaluation of the change of intensity of tinnitus in decibels was carried out before/after the general osteopathic treatment of the osteopathic group (OG) and/or before/after the guidance for progressive muscle relaxation of Jacobson of the control group (CG).

The value “0” shows that there has not been any change between the first and second measured value. 25%, 50%, 75% each show an improvement in percentage, i.e. a reduction in volume of the tinnitus tone and an improvement of 100% means “no tinnitus”. Minus values indicate an aggravation, i.e. an increase in volume of the tinnitus tone.

42 patients were included in the measurements of the intensity of tinnitus, 2 patients perceive an ear noise which does not correspond to a tone. This is also why problems in the recording of the volume resulted and the measuring was stopped.

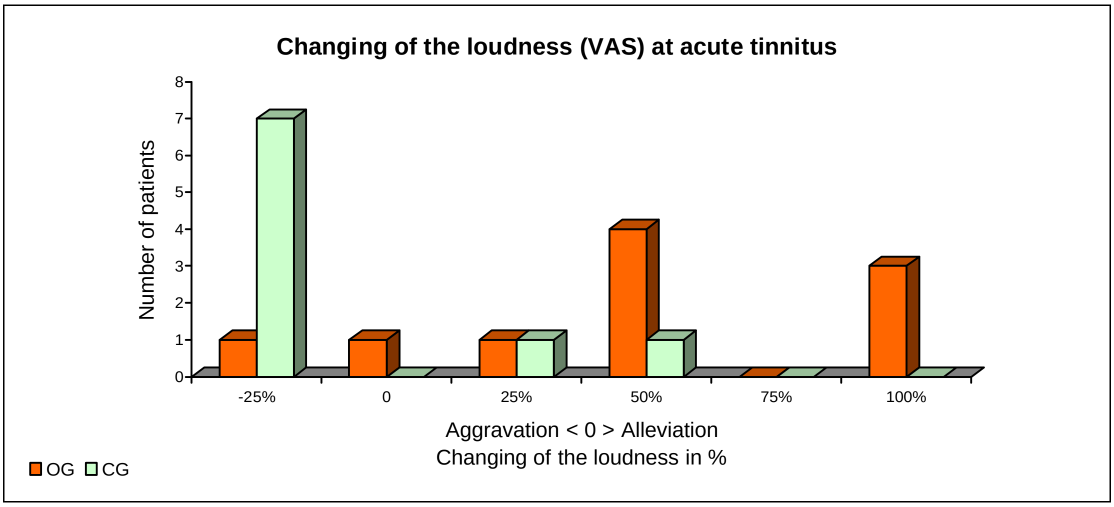
Comparing the three images of the measurements of the intensity of tinnitus in decibels between the acute, subacute and chronic group of patients, one can see that particularly in the osteopathic group of patients suffering from acute tinnitus, a positive change can be registered. With 4 patients a reduction in volume of 25% was measured, with 2 patients a reduction of 50%. 3 patients were completely freed from the annoying ear noise/tone after the general osteopathic treatment, in contrast to the control group**,** which showed only very low fluctuations of +/- 25%.

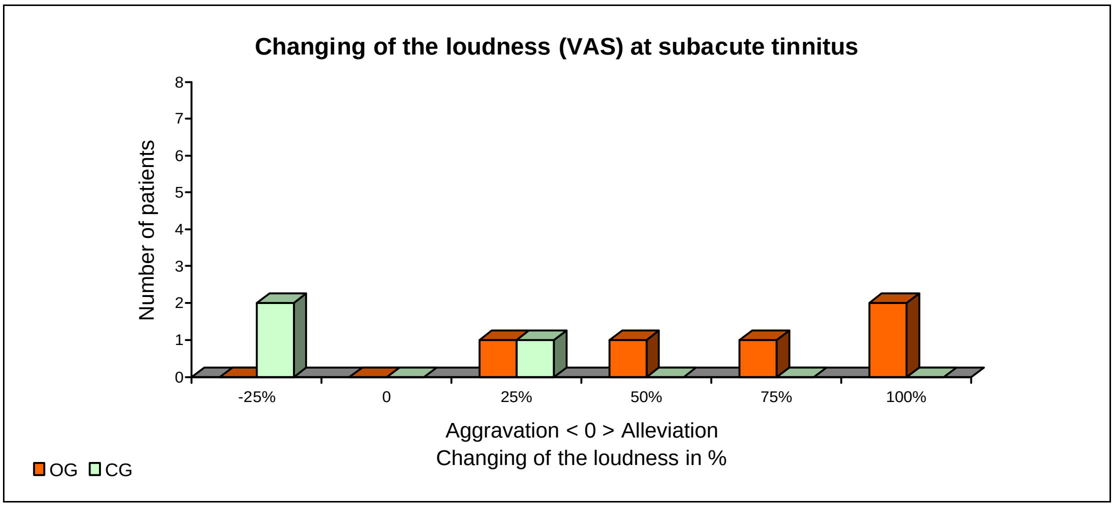
However, it can be seen that success in the osteopathic group is connected with duration. In the subacute stage only 3 patients showed minor relief of 25%. One patient was cured spontaneously after the venous discharge from the head had been released and relaxation of the cervical fascia.

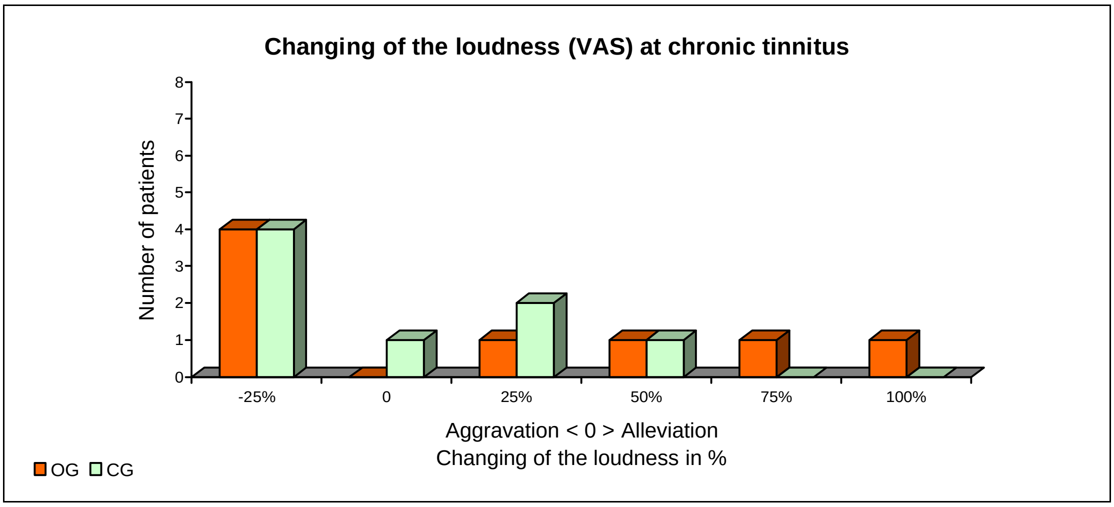
The values of the control group in the subacute stage nevertheless show a small decrease in volume for 1 patient of 25% and a further of 50%, as opposed to the chronic control group, which shows virtually no change and/or even by the relaxation minor aggravation in 4 patients.

The results of the osteopathic group, comprising patients suffering from chronic tinnitus, showed no changes either. On the contrary, measurements with one patient showed a slight increase in decibel.

Evaluation of the change of the subjective loudness of tinnitus by means of visual analogue scale (VAS), comparing osteopathic group (OG) with control group (CG)







The visual analogue scale calculates the subjective value of the volume of tinnitus.
Judging the first view of the acute group of patients, it can be seen that the subjective perception of the patients certainly shows different values than the measurement. The patients who noticed a decrease in volume clearly felt greater subjective relief than the measured values showed, which confirms Goebel's statement (2001) that very often a substantial discrepancy exists between the psychoacoustic categorised intensity of tinnitus and the subjectively indicated volume of tinnitus. (Goebel, 2001, p. 25)

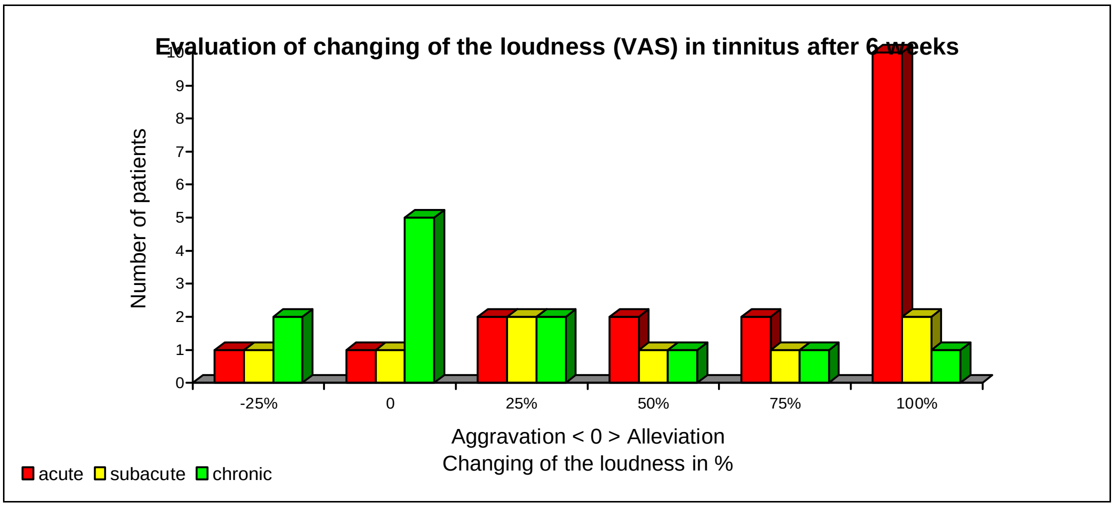
Here too it can be seen that the success rate in the osteopathic group decreases the longer the patients suffer from tinnitus.

The subjective results of the control group, which are more or less the reverse of those of the osteopathic group, are interesting. In the acute and subacute stage they show a clear increase in the subjective volume of tinnitus. Also in contrast to the measurements of the intensity of tinnitus, which show that there is hardly any change. In the course of the anamnesis the patients of the study describe that in their situation they can hardly bear peace and quiet, because in silence they perceive the ear noise to be even louder. The more they think about it, the more the noise becomes evident to them.

It is only in the chronic stage that patients with tinnitus have come to terms with it. All of them found the relaxation method according to Jacobson pleasant, relaxing and reassuring. One half (4 patients) felt a subjective decline, the other 4 patients describe as well that by taking a proactive approach and listening to it, they perceive the tinnitus to be stronger, although in day-to-day life it has become insignificant.

Comparing the results of psychoacoustic comparative measurements for the determination of the intensity of tinnitus with those of subjective scales of tinnitus volume, Dräger's (2000) argument is confirmed, with the result that both methodical approaches show not a low correlation. Therefore, in quite a lot of cases you can see that the level of masking in the area of the main frequency of tinnitus lies only a few decibels over the hearing threshold level in this area, whereas the subjective volume of tinnitus is often indicated as unbearably loud. Here you can see how much tinnitus is subject to the subjective experimental sphere. (Dräger, 2000, p. 22)

Evaluation of the change of the subjective loudness of tinnitus by means of visual analogue scale with all patients (osteopathic and control group together) after 6 weeks

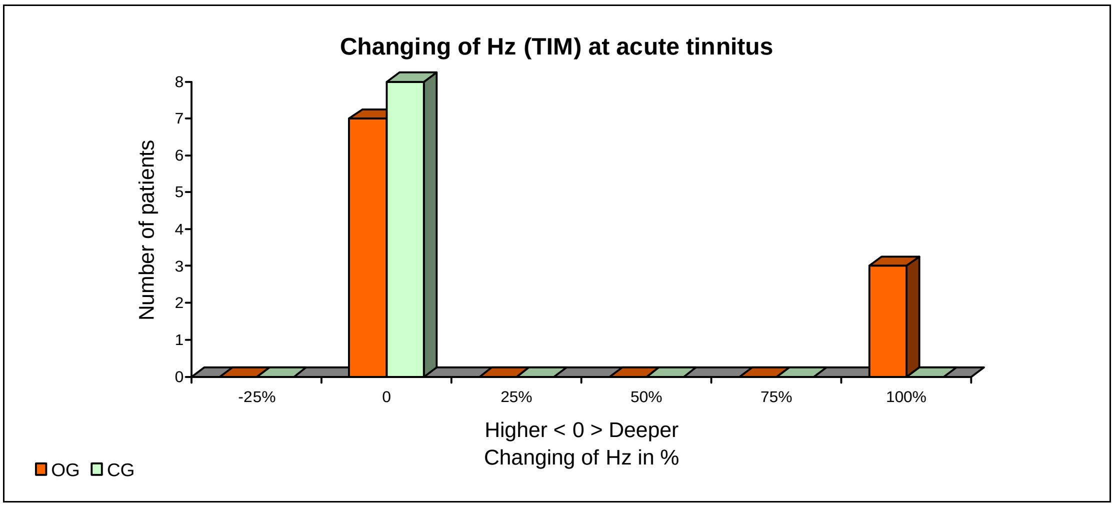


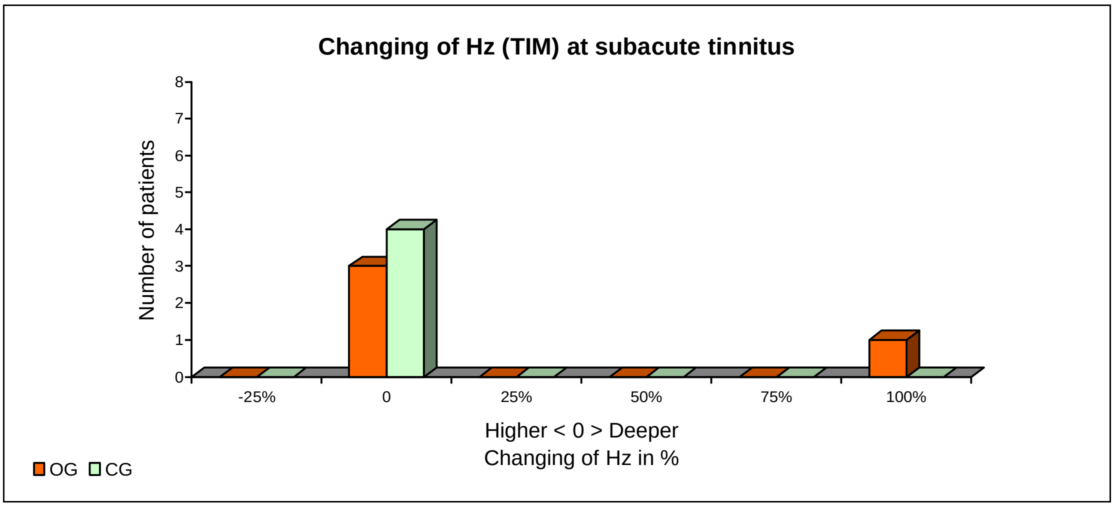
All patients, both in the osteopathic group and control group (after the data collection had been completed), received three osteopathic treatments. The number of patients, however, was reduced to 38, after 6 patients had not kept the set appointments and were therefore excluded from the statistics.

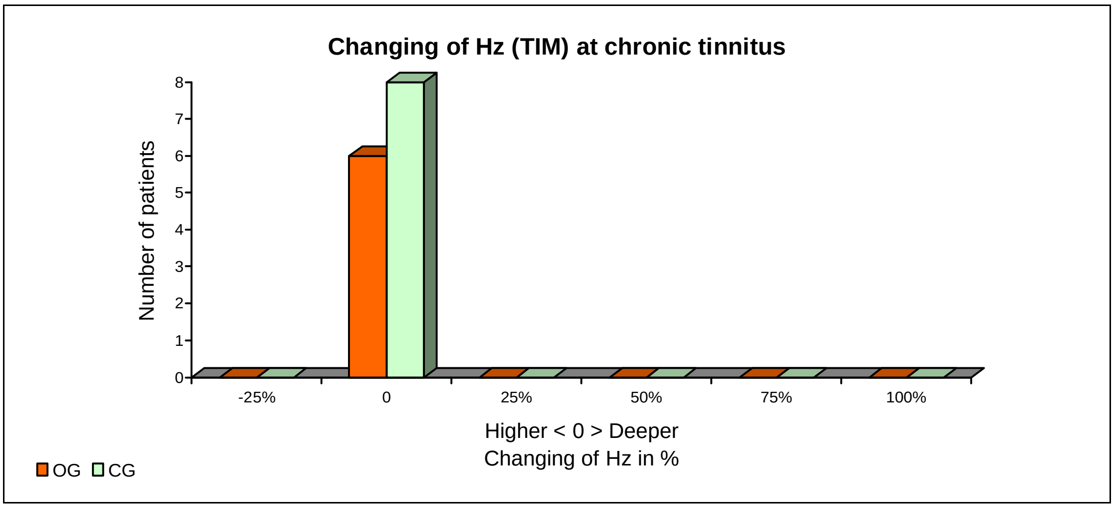
The comparison between the values of questionnaire 1 and the values of questionnaire 2 shows that 10 of the patients suffering from acute tinnitus, 2 of the patients suffering from subacute tinnitus and one of those suffering from chronic tinnitus, have been healed. This is one third of all patients.

Furthermore it can be noted that the worsening factor in the form of an increase in volume dropped considerably compared to the initial values.

Measurements of tinnitus intensity in Hertz (Hz) in comparison between osteopathic group (OG) and control group (CG)







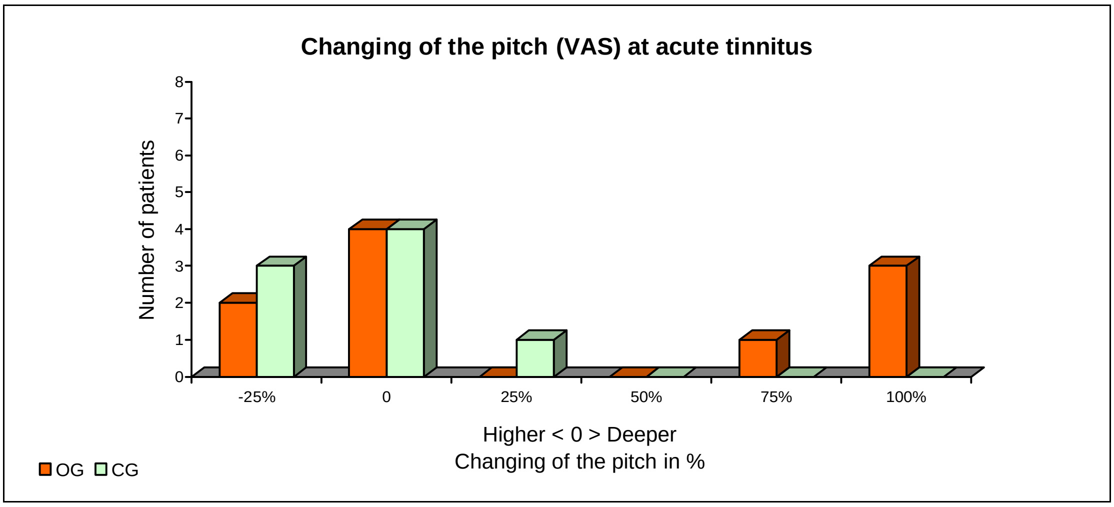
For the evaluation of the frequency of the tinnitus tone the data of 41 patients was used. 3 patients indicated an ear noise which was not comparable to a tone and was not measurable above a tone.

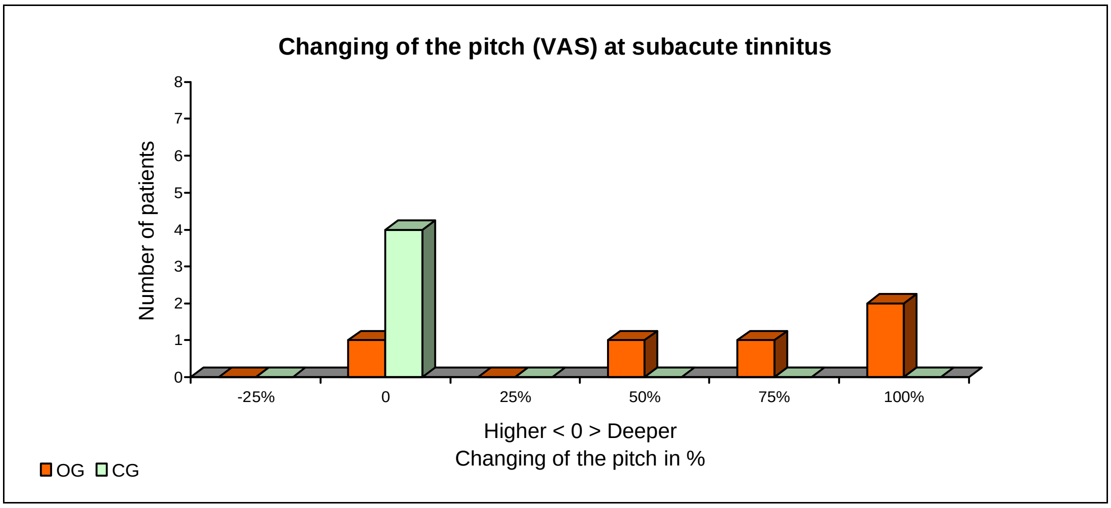
Positive values mean that the tone has become deeper, 100% means that the tinnitus has disappeared altogether. Negative values mean that the tone has become higher.

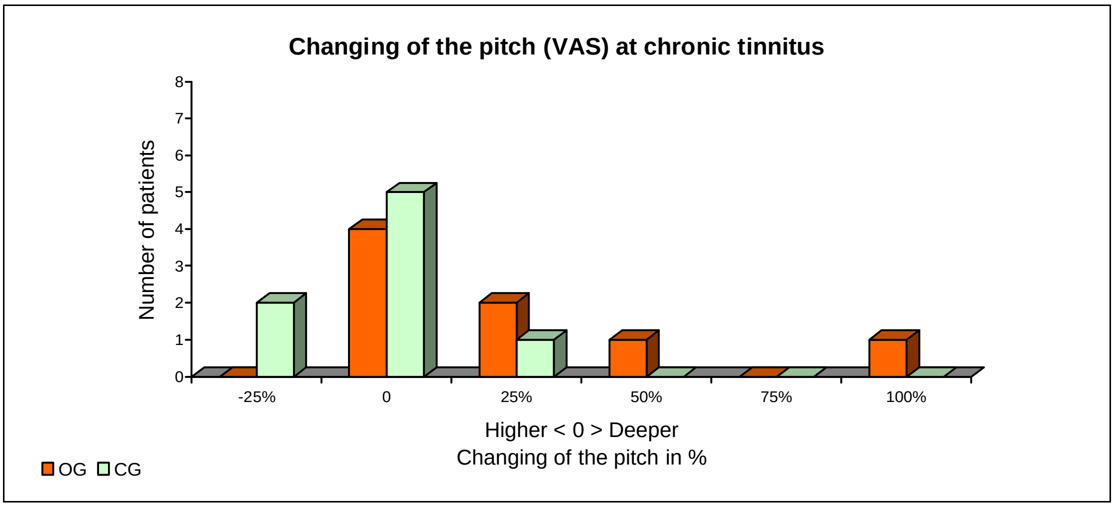
It can be seen from these statistics that measurements of intensity of tinnitus for the evaluation of the change of the frequency in Hertz do not show any change in any stage of tinnitus, apart from the 4 patients who were spontaneously cured by osteopathic treatment.

The pitch of the tone (high tone/deep tone) can therefore be affected neither by general osteopathic treatment nor by progressive muscle relaxation of Jacobson.

Evaluation of the change of the pitch of tinnitus by means of visual analogue scale (VAS) in comparison between osteopathic group (OG) and control group (CG)







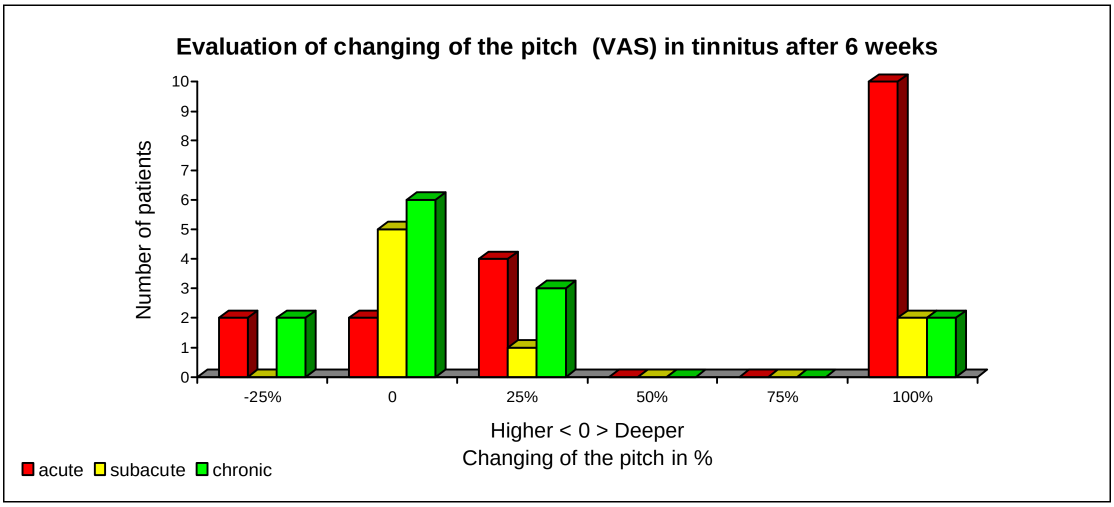
The visual analogue scale for the evaluation of the subjective pitch of the tone was completed by 43 patients.

In comparison with the measurements of intensity of tinnitus in Hz, the information of the visual analogue scale for the evaluation of the subjective change of the pitch of the tone clearly shows different values.

In the case of 22 patients, the subjective perception of the pitch of the tone neither changed after the general osteopathic treatment nor after the progressive muscle relaxation of Jacobson**,** but 15 patients of the group indicated that they feel that at least the tone has changed its height. 6 patients indicated that the tone has disappeared.

It was clear, however, that a subjective deepening of the tone was perceived to be a relief, a heightening was worse.

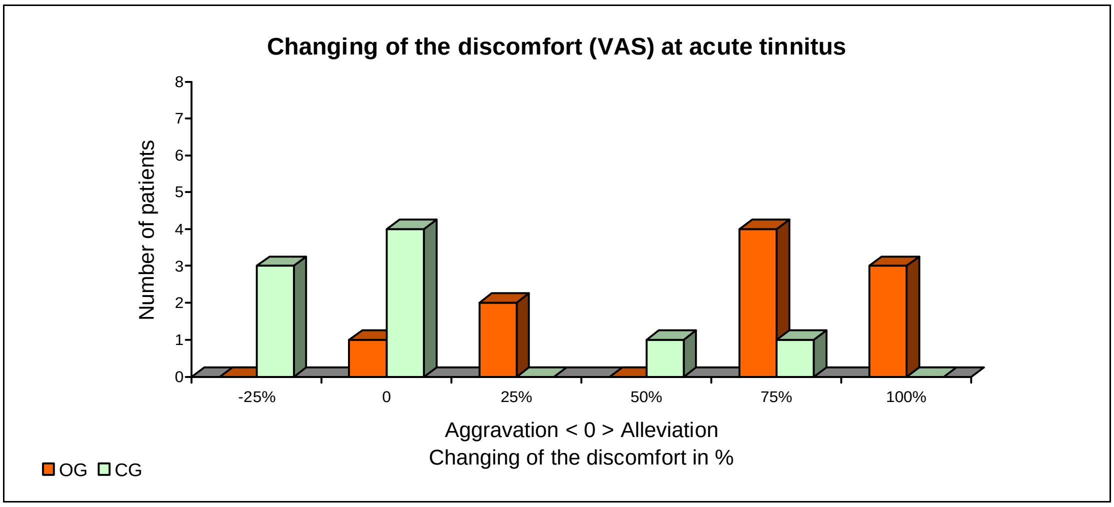
Evaluation of the change of the subjective perception of the tinnitus pitch by means of a visual analogue scale (VAS) with all patients (osteopathic and control group together) after 6 weeks

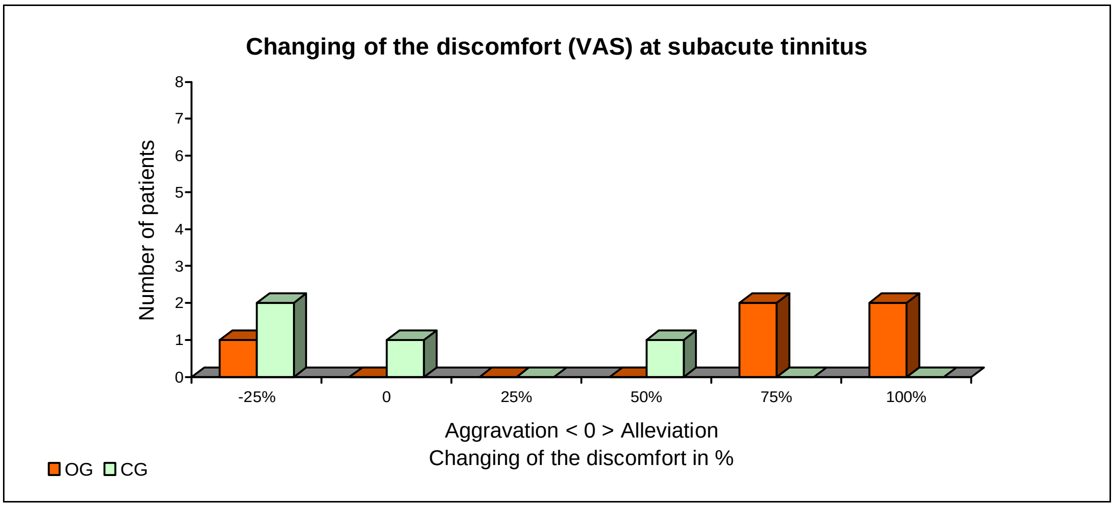


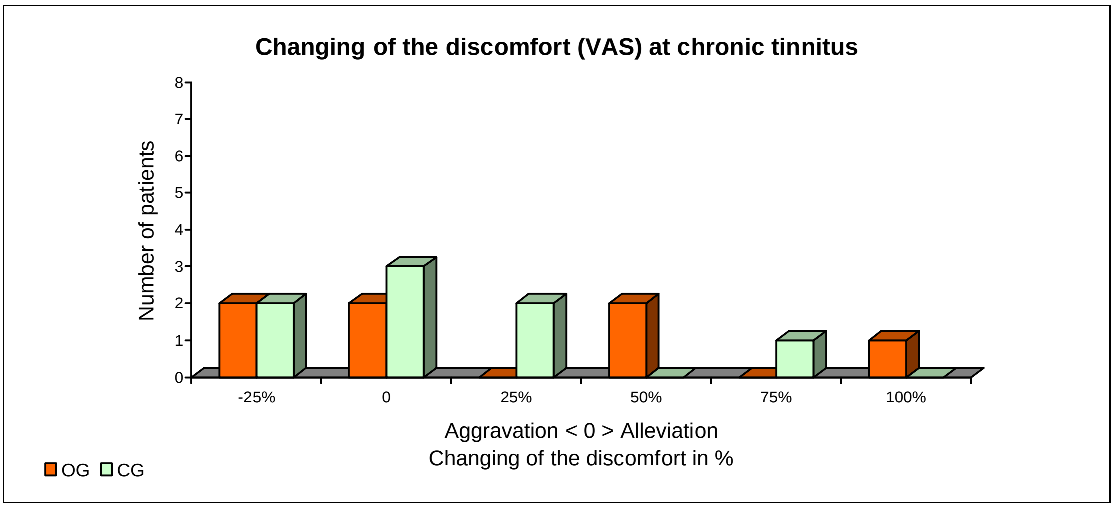
Here too, in this evaluation of the subjective perception of the pitch of tinnitus, one can see that except for the change of 100% (i.e. complete disappearance of tinnitus), there are low subjective fluctuations similar to those in evaluations after treatment.

Based on the fact of the measuring data of the intensity of tinnitus in Hz it can be assumed, however, that the evaluation of the pitch of tinnitus is irrelevant.

Evaluation of the change of stage of discomfort by means of visual analogue scale (VAS) in comparison between osteopathic group (OG) and control group (CG)







For the evaluation of the degree of discomfort, the anamnesis shows that most patients feel exhausted in certain way and that they are in an extraordinarily difficult time or situation. Barral (2006) says that major physical and emotional difficulties, stress, severe illnesses, serious family problems or depression exhaust our reserves, by using our deep energy. The kidneys – in particular the left kidney – are the organs which correspond to this energy. (Barral, 2006, p. 199)

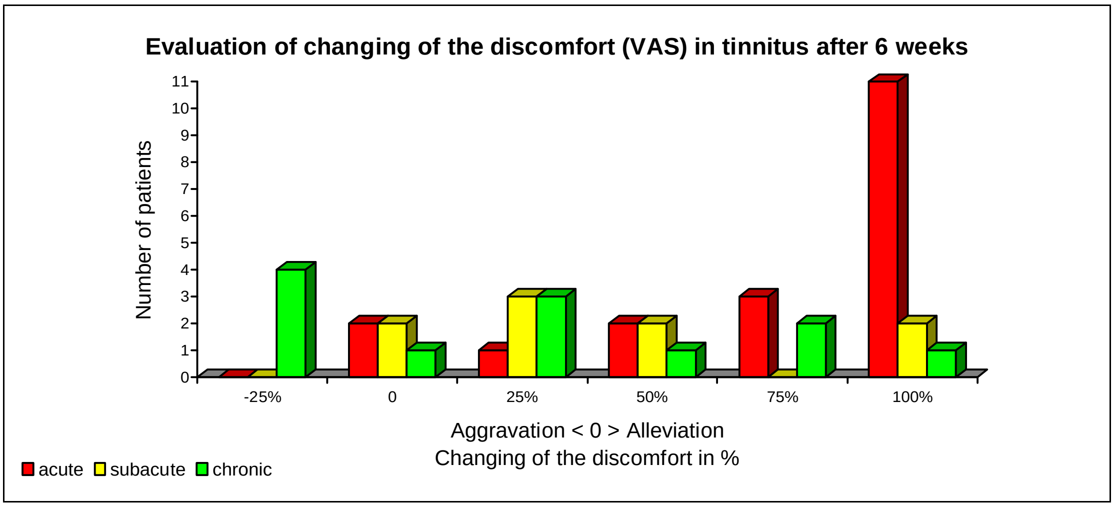
According to traditional Chinese medicine these “kidneys” correspond to the element of water and represent matter and essence. The emotion assigned to them is fear. (Ploberger, 2005) Most patients showed a pattern of tension, which was integrated as a result of fear.

Judging the change of the degree of discomfort, comparing osteopathic group and control group from this angle, you can see that the relationship is similar to the judgement of the subjective volume of tinnitus. Particularly in the acute stage, and still slightly in the subacute stage, it shows that the patients attain a rising tendency towards a relief of the degree of discomfort by means of osteopathic treatment, whereas the control group patients even perceived the tinnitus to be louder, probably because of actively listening to it.

Both groups balance out with each other the longer tinnitus in the chronic stage lasts.

With chronic tinnitus there is a tendency towards reduction in the level of discomfort. The patients gradually become accustomed to the noise and learn how to direct their attention to other things. The study shows that patients suffering from chronic tinnitus do not actually want to speak about it in concrete terms or think about it, because they think that this could make it come back again.

Evaluation of the change of subjective perception of the level of discomfort of tinnitus by means of visual analogue scale (VAS) with all patients (osteopathic and control group together) after 6 weeks



After 6 weeks and 3 treatments the majority of the patients experienced a relief or possibly an improvement in their psychical situation. Even those 9 patients who did not feel a subjective change or sometimes even a worsening of the discomfort of tinnitus found that the general osteopathic treatment gave a new perspective to their life – caused by either improved mobility, relief from pain, improved breathing or more vitality.

Evaluation and assessment of the change of tinnitus character by means of questionnaire 1 and 2 (direct change) and of questionnaire 1 and evaluation form (long-term change)

With regard to the character of tinnitus, hardly any immediate (comparing the osteopathic group with the control group) or long-term (assessment of all patients) changes were noted. Only one patient stated that the hissing in a singing character had changed into whispering singing from the distance, which already meant relief to him because his attention was no longer drawn to it.

8. Discussion

Considering all the patients who participated in this study, I noted inner dural/fascial tension along the central axis, especially from the thoracic diaphragm and the cervicothoracic transition onwards in cranial direction to the synchondrosis sphenobasilaria and along the cervical fascia (in most cases caused by long lasting stress and anxiety postures; in two cases caused by a nephroptosis) in 90 per cent of the patients. Over the temporalia bones, which are frequently fixed in an inner rotation or oppositional rotary dysfunction, I observed substantial dural tension over the tentorium cerebelli. 80 per cent of the tinnitus patients had a diagonal wrinkle across their earlobes, it seemed as if the increased tension in the tentorium cerebelli were pulling their ears inwards. It can be assumed that these structural, partially fibrotic fixations not only impede the physiological rhythm of cranial breathing and therefore the vitality, but also irritate the vascular system (see chapter 5.1.7). On the one hand this concerns the internal carotid artery, which supplies the brain with blood and has both fluidally and via the fascial loge of the carotid artery an impeding influence on rotation possibilities of the os temporale within the primary respiratory mechanism. On the other hand the jugular vein, sinus petrosus superior and inferior and sinus sigmodeus, which are responsible for the drainage of the venous blood from the cranium, are impeded in their function by the dural tensions and/or by the immediate contact with the dysfunctional temporal bone. I assume that this stasis causes a change in the chemistry, a retention of metabolic products, lessened alkalinity and increased toxicity which might lead to a gradual failure of the axonal conduction and synaptic transmission and therefore to the tinnitus symptom (see chapter 2.4).

Additionally I noticed functional problems with the cervical spine (C0-C4) in 70 per cent of the tinnitus patients. In 20.5 per cent of the patients the volume of the tinnitus tone changed when making movements (i.e. rotation movements) but not the pitch (see chapter 7; changing factors).

It showed me that the strong tuba auditiva technique indeed had a substantial influence on alleviating the tinnitus volume and discomfort, but this success does not last long; often only as long as one maintains the pressure in the outward rotation. This suggests that this impeded mechanism is only the result, but hardly the trigger of the tinnitus (cf. chapter 5.1.1).

The experience gained from this osteopathic study showed me the tinnitus symptom as a warning sign of our hearing system. It can be compared to a valve on a pressure cooker. When the vessel seals after some time of pressure increase, the pressure within increases so rapidly that the valve starts to whistle – so we can react immediately and remove the pot from the stove. The human hearing system is similar. The time span where the inner pressure gradually increases often stretches over years and decades. As long as the reciprocal tension membranes in the body centre and the myofascia, which connect everything, are flexible and vital, all states of tension can be balanced to secure the flow of the body liquids which maintain the physiologic inner environment. When, for a variety of reasons (mostly negative emotions, stress etc.), these structures gradually become fibrotic and stiff, as described in Schleip's study (2006) (see chapter 5.3), not only the locomotor system becomes tired and inflexible, also the vessels and nerves become constricted. We can assume that in an extreme case the hearing system expresses this unbearable inner pressure as tinnitus.

Basically we can say that tinnitus patients, first and foremost in an initial state (in an "emergency") should receive osteopathic treatment immediately or as soon as possible to have good chances of success. This is also the opinion of several authors such as Liem (1998) in chapter 4.2 and Fuhrmann (2006). The best chances of alleviating the situation are in the acute stage, when this condition has not been structurally (cranial, fascial or visceral) fixed and when the information "tinnitus" has not been integrated in the central nervous system yet. This explains why the success rate in the case of acute tinnitus patients is higher than in case of chronic tinnitus patients, as the statistical evaluation shows.

It is to be noted, however, that tinnitus which is caused by a degenerative process, e.g. a noise trauma, is unlikely to be influenced by general osteopathic treatment because broken off or damaged sense hair cells cannot regenerate.

If the original problem lies in a stasis caused by long term states of tensions in the myofascial, cranial or visceral system, then we can certainly bring relief, also for the hearing system, by a general osteopathic treatment.

When I consider the 5 patients in the treatment group of this study who were spontaneously relieved from the tinnitus symptom after osteopathic treatment and the 13 patients (treatment and control group) who were finally healed after six weeks, I can say that all of them were supported this theory. Relieving the vessels by balancing in the cranial, visceral and fascial system became the first priority. 2 patients showed remarkably positive results of relieving of tinnitus when their second-degree nephroptosis was treated osteopathically. Furthermore, in the case of a patient with acute tinnitus the symptom disappeared after a talus correction and release of the fascial restrictions along the lateral line (see chapter 5.3.2.2) after a long forgotten supination trauma of the foot one year previously.

In a chronic stage the influence of osteopathic treatment on an immediate change of the tinnitus becomes smaller. Long-term studies would be required here, in particular studies which integrate the measurement of the discomfort level and secondary symptoms caused by continual emotional strain, as described in a further osteopathic tinnitus study of Schlatte-Cehovin.

I wish to express, however, that osteopathy alone cannot bring an end to the tinnitus symptom. What it can do is bring relief to the patient in the extreme situation. Achieving success in the long term is largely dependent on the patient – whether he/she thinks about his/her life and emotional situation and adds balancing and relaxing factors in life.

The summary of this osteopathic study shows that osteopathy can influence the tinnitus symptom, mostly when acute, in its volume and subjective discomfort whereas the pitch and character are hardly likely to change. Osteopathy can be described as a “soft” method to bring relief in an emergency situation, so that the person becomes aware of his/her personal limits and finds a way to recover.

It is to be noted, however, that the following problems arose in this study in the course of data collection and tinnitus analysis:

A randomisation of this study was not possible because not all patients were at our disposal at the beginning of the study. The patients were referred to us from different institutions (see chapter 6.1) only on a one-by-one basis. It was hardly possible to compare the patients because of the numerous possibilities of origin, trigger factors, characters and pattern of the tinnitus. The division of the patients into the groups acute–subacute–chronic, and alternating in the treatment and control group resulted in very small groups, comprising only a few patients; therefore the results can by no means be generalised. I can say, however, that this study is an attempt to show the effects of osteopathic treatment.

Furthermore, the statistics show that tinnitus is often accompanied by impaired hearing (see chapter 7: Additional problems). In this study 14 patients told us of their hearing impairment, which had been medically proved, whereby 7 further patients said they had a feeling of impaired hearing but no medical proof. This is relevant for those tinnitus patients where an extremely loud tinnitus sound was measured by audiometer. In these cases we can assume that they have impaired hearing in exactly the same frequency range as the tinnitus – see description in chapter 6.3.2. According to Goebel (2001) the aim of a tinnitus diagnosis is first to collect data on the extent and localisation of a hearing impairment (Goebel, 2001, p. 25). We had only the medical results from the patients in the acute group at our disposal.

With regard to the measurement of the tinnitus intensity, which gives the tinnitus analysis a relative “objectivity”, it is to be noted that even this “objective” high-tech method includes to a great extent the process of subjective perception by the patient – and exactly in the disordered modality.

We would have to carry out a precise differentiation in the psycho-acoustic tinnitus diagnosis, not only determining the main frequency of tinnitus characterisation but also determining the tinnitus masking and recording the minimum masking level. Tinnitus masking refers to a cover-up test with “white” noise or broadband noise (i.e. a noise where all frequencies are represented with the same intensity). In this study we tried to determine the volume and frequency of the tinnitus by sinus tones and narrowband noises alone (tinnitus matching), so it was not possible to determine all of the sounds and the process had to be cut short (Goebel, 2001, p. 327).

Also the results gained from the visual analogue scale are difficult to evaluate. The visual analogue scale is a subjective instrument, we do not know about its reliability, especially when trying to assess the subjective pitch on a vertical scale.

Regarding the comparison with the control group I would like to mention that Hainbuch (2004) describes very successful results with Progressive Muscle Relaxation according to Jacobson, but not until one month after daily periodical exercises. Thus it is questionable if the results of the control group in terms of the relaxing effects can be evaluated objectively, because most of these patients explained that not relaxation but the tinnitus itself became dominant.

When we look at the numerous studies concerning tinnitus, especially in the psychological field, but also ENT and surgery, which are described by different authors and specialists such as Feldmann (1998) or Goebel (2001) et al., then, based on my experience, osteopathic studies concerning tinnitus could serve medicine as a new approach in the treatment of this symptom in the future.

The study of the German ENT Congress 2003 on the topic “Integrated Care of Tinnitus” (Maier 2003, see chapter 2.5) makes clear that a collaboration of specialists from different fields (ENT, neurology, psychology, orthopaedics, dental/oral surgery, hearing devices, relaxation therapy, physiotherapy, osteopathy) shows considerable success. The advantage is that the patient is referred to a specialist according to the cause of the tinnitus and can be treated specifically. Furthermore, a much higher number of tinnitus patients can be treated, so we can gain sound results.

From an osteopathic point of view a collaboration of several osteopaths who collect data for a tinnitus study independent of each other over a longer time span, would be interesting. This would provide a high number of tinnitus patients, under consideration of the exclusion criteria (see chapter 6.2), for inclusion in the study. Thus, a purely osteopathic validity is guaranteed.

I support the opinion of Dräger (2006), Plothe (2006) and Maier (2003), who say that because of the good results osteopathy has shown in the treatment of tinnitus patients, it should be integrated in the basic services of the current medical system, especially in the acute cases. Hereby, not only the methodical components but also the individual patient should stand in the foreground.

9. Thanks

Dr. Kilian Dräger, DO, whose dissertation (2000) was an inspiration for this study and in high respect of his commitment to osteopathic research regarding tinnitus

Prim. Dr. Meindl who kindly provided the audiometer for the evaluation of data and encouraged me in the project

OA Dr. Langmayr und MR Dr. Gahleitner, for the referral of patients for this study and for their belief in my osteopathic work

Andrea Grabner, my colleague, for the numerous talks and discussions about tinnitus and for help in obtaining research literature

Dipl.Ing. Manfred Hübsch for his help with internet research

Margit Plamberger and Margarete Barth who reviewed the study in German with great precision

Shona Feldmann, Ingrid Falkner, Hannah Dietze, Wolfgang Spachinger who were a precious help in translating

David Wilson, BA Hons., for proofreading and much appreciated comments

Dieter Plamberger, my dear husband, for the statistical evaluation and graphic design of the study; special thanks too for his tremendous mental support and encouragement throughout this demanding time for the family

Jana and Nicole, my wonderful children, who supported me at all times with much love this year despite many sacrifices

10. Bibliography

Ackermann, M.: Die Kultur des Hörens, Falkenberg, Hassfurt/Nürnberg, 2003

Arlot, J.: Os temporale, unveröffentlichte Vortragsmitschrift, WSO, Vienna, 1997

Arlot, J.: Liquor cerebrospinalis, unveröffentlichte Mitschrift, WSO, Vienna, 1998

AWMF online: Leitlinien der Deutschen Gesellschaft für Hals-Nasen-Ohren-Heilkunde, Kopf- und Hals-Chirurgie, www.uni-duesseldorf.de/WWW/AWMF/11/017-064.htm (downloaded: 9.12.2005), 1998

Barral, J.-P., Mercier, P.: Visceral Manipulation, Eastland Press, Seattle, 1997

Barral, J.-P.: Lehrbuch der Viszeralen Osteopathie (2), 2nd ed., Elsevier, Munich, 2005

Barral, J.-P.: Die Botschaften unseres Körpers, Südwest Verlag, Munich, 2006

Biesinger, E.: Endlich Ruhe im Ohr, 3rd ed., Trias, Stuttgart, 2005

Diolosa, C.: Tinnitus und Ohrensausen, DVD-Videovortrag, Avicenna-Institut, 2004

Boenninghaus, H.G./Lenarz, T.: Hals-Nasen-Ohren-Heilkunde, 12th ed., Springer, Heidelberg, 2005

Dräger, K.: Tinnitus und seine Reaktion auf osteopathische Behandlung (Dissertation), Hamburg, 2000

Dräger, K.: Das Os temporale und seine Beziehungen, Deutsche Zeitschrift für Osteopathie 3/2006, p. 17-23

Drews, U.: Taschenatlas der Embryologie, Thieme, Stuttgart, 2006

DTL – Tinnitus: Tinnitus, www.tinnitus-liga.de/tinnitus.htm (downloaded: 9.12.2005), 2003

Duus, P.: Neurologisch-topische Diagnostik, 5th ed., Thieme, Stuttgart, 1990

Feldmann, H.: Tinnitus, 2nd ed., Thieme, Stuttgart, 1998

Frick, H., Leonhardt, H., Starck, D.: Spezielle Anatomie, Thieme, Stuttgart, 1987

Fuhrmann, M.: Tinnitus aurium – Wenn das Ohr pfeift, Deutsche Zeitschrift für Osteopathie 3/2006, p. 40

Goebel, G.: Ohrgeräusche, Psychosomatische Aspekte des komplexen chronischen Tinnitus, 2nd ed., Urban und Vogel, Munich, 2001

Hainbuch, F.: Muskelentspannung nach Jacobson, Gräfe und Unzer, Munich, 2004

Hellbrück, J.,Ellermeier, W.: Hören, 2nd ed., Hogrefe-Verlag, Göttingen, 2004

Janda, P.: Tinnitus, www.netdoktor.de/krankheiten/fakta/ohrensausen.htm (downloaded: 10.8.2006), 2006

Jealous, J.S.: The Biodynamics of Osteopathy in the Cranial Field (osteopathic audio training programme), Jolandos, Paehl, 2006

Liem, T.: Kraniosakrale Osteopathie, Hippokrates, Stuttgart, 1998

Liem, T.: Praxis der Kraniosakralen Osteopathie, 2nd ed., Hippokrates, Stuttgart, 2003

Ligner, B., van Assche, R.: Gelenke der unteren Extremität, Verlag für Osteopathie Wühr, Kötzting/Bayer Wald, 1993

Magoun, H.T.: Osteopathy in the cranial field, 3rd ed., Journal Printing Company, Kirksville, 1976

Maier, H./Lang, M./Mühlmeier, G.: Tinnitus Therapie – Integrierte Versorgung: Vorschlag zur ambulanten Tinnitus Therapie (modellhaft im Raum Ulm), Publication: dt. HNO Kongress, Ulm, 2003

Mayer, M.: Pilotstudie zur Untersuchung der Wirksamkeit der osteopathischen Tuba auditiva Technik bei akutem Tinnitus mit und ohne Hörstörungen, AFO, Deutschland, 2003

Myers, T. W.: Anatomy Trains – Myofasciale Meridiane, Urban & Fischer, Munich, 2004

Nusselein, H.: Entrapment Neuropathy of the central nervous system, unpublished lecture notes, WSO, Vienna, 2000

Paoletti, S.: Faszien, Urban & Fischer, Munich/Jena, 2001

Ploberger, F.: Nieren (TCM), unpublished lecture notes, Waidern, 2005

Ploberger, F.: Gesichtsdiagnostik in der TCM, unpublished lecture notes, Waidern, 2006

Plothe, C.: Tinnitus, Deutsche Zeitschrift für Osteopathie 3/2006, p. 25-29

Putz, R., Pabst, R.: Sobotta – Atlas der Anatomie des Menschen, 20th ed., Urban & Schwarzenberg, Munich, 1993

Ratio, A., Klinische Osteopathie: HNO: Vertigo und Tinnitus, unpublished lecture notes, WSO, Vienna, 1999

Resch, K.L.: Kommentar zur Pilotstudie (Mayer 2003), Deutsche Zeitschrift für Osteopathie 3/2006, p. 7

Rohen, J. W.: Funktionelle Anatomie des Nervensystems, 4th ed., Schattauer, Stuttgart/New York, 1985

Rütz, M.: Das Ohr: Anatomie und Physiologie, Deutsche Zeitschrift für Osteopathie 3/2006, p. 9-15

Sammut, E., Searle-Barnes, P.: Osteopathische Diagnose, Pflaum, Munich, 2000

Schaaf, H., Klofat, B., Doelberg, D., Hesse, G.: Psychosomatik rund ums Ohr: Tinnitus, Gleichgewicht & Schwindel, www.drhschaaf.de/Tinnitus (downloaded: 29.11.2005), 2004

Shaver, T.: Biodynamische Cranialosteopathie, unpublished lecture notes, St. Gilgen, 2006

Silbernagl, S., Despopoulos, A.: Taschenatlas der Physiologie, 6th ed., Thieme, Stuttgart/New York, 2003

Schleip, R., Klingler, W.: Eine Studie über die Fähigkeit der Faszien, sich aktiv zu kontrahieren und zu entspannen und dabei die Biomechanik des Körpers zu beeinflussen, Zeitschrift: Osteopathische Medizin 1/2006, p. 19-20

Stark, J.: Stills Faszienkonzepte, Jolandos, Pähl, 2006

Still, A. T.: Philosophy of Osteopathy, originally published by the author, Kirksville, 1899

Still, A. T.: Philosophy of Osteopathy. Kirksville, 6th ed., American Academy of Applied Osteopathy, Ohio, 1986

Still, A. T.: Osteopathy, Research & Practice, reprint by Eastland Press, Seattle, 1992

Sutherland, W. G.: The Cranial Bowl, reprint by the Cranial Academy, Indianapolis, 1948

Sutherland, W. G.: Contributions of thought, Sutherland Cranial Teaching Foundation, Fort Worth (Texas), 1967

van Dun, P.:Embryological study of the spinal dura and its attachment into the vertebral canal, unpublished lecture notes, Gars am Kamp, 2006

11. List of Illustrations

12. Appendix

List of abbreviations

CRI Cranial Rhythmic Impulse = declaration of frequency of PRM

PRM Primary Respiratory Mechanism

SSB Synchondrosis sphenobasilaris

VAS Visual analogue scale

TIM Measurement of tinnitus intensity

dB Decibel

Hz Hertz

OG Osteopathic group

CG Control group