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Functional ear symptoms referred to an otology clinic: incidence, co-morbidity, aetiological factors and a new experience-driven clinical model

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Main Article

Mr N Patel takes responsibility for the integrity of the content of the paper

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Abstract

Objective. This study aimed to review the incidence and co-morbidity of functional ear symptoms in new referrals to an adult otology clinic and present a clinical model based on neuroscientific concepts.

Method. This was a retrospective review of 1000 consecutive new referrals to an adult otology clinic.

Results. Functional disorder was the primary diagnosis in 346 patients (34.6 per cent). Functional ear symptoms included tinnitus (69.7 per cent), imbalance (23.7 per cent), otalgia (22.8 per cent) and aural fullness (19.1 per cent), with more than one symptom occurring in 25.1 per cent of patients. Co-morbidities included sensorineural hearing loss (39 per cent), emotional stress (30 per cent) and chronic illness (22 per cent).

Conclusion. Functional disorders commonly present to the otology clinic, often in the presence of emotional stress or chronic illness. They occur because of adaptation of brain circuitry to experience, including adverse events, chronic illness and fear learning. This study presented an experience-driven clinical model based on these concepts. An understanding of these principles will significantly aid otolaryngologists who encounter patients with functional ear symptoms.

Introduction

Functional disorders are defined by the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders-5 as one or more symptoms that affect a patient's movement or senses and are outside of their conscious control. The patient must not be able to attribute their symptoms to drug use, physical or neurological conditions and may attribute their symptoms to a traumatic or stressful event.[1]

Functional neurological disorders are documented in the neurology literature and comprise 16 per cent of patients referred to neurology clinics, second only to headaches.[2] A diverse range of functional disorders, including tinnitus, chronic pain and depression,[3] fibromyalgia,[4] visual snow syndrome,[5] migraine,[6] and central hearing loss[7] demonstrate similar brain network dysfunction and may provide an aetiological basis for understanding the emergence of certain idiopathic otological symptoms (i.e. functional ear symptoms).

Tinnitus and imbalance often present to the otology clinic as functional symptoms, manifesting because of adaptive brain circuit dysfunction in the absence of active physical disease. Half of dizziness referrals to neurology have been classified as functional.[2] Primary tinnitus, persistent posturo-perceptual dizziness and vestibular migraine are recognised functional disorders.[8–10] Patients with migraine often have audiovestibular symptoms, but the type of migraine has no bearing on audiovestibular abnormality,[11] suggesting a mechanistic overlap in central sensory processing. Otalgia and aural fullness often occur as unexplained presenting symptoms to the otology clinic, together with tinnitus and imbalance, which suggests a common functional mechanism. Aural fullness has been reported to occur in 13.4 per cent of patients as an unexplained or idiopathic symptom.[12] These patients experience aural fullness despite normal examination and investigations and can improve with migraine treatment, supporting the idea of a common central mechanistic overlap.[13] Unexplained otalgia has also been associated with migraine mechanisms.[14] It is also interesting to note that idiopathic aural fullness symptoms have been reported to improve with the administration of an autonomic nerve blocking agent, again indicating a potential central origin of this symptom.[15]

Various factors have been implicated in the emergence of functional disorders that may be related to neurological adaptation or maladaptation, to challenging experiences, and to perceived threats. These include childhood adversity,[16] emotional stress,[17] physical trauma[18] and sleep deprivation.[19] A recent meta-analysis confirmed that adverse life experiences, especially childhood adversity, are a predisposing factor to the development of functional neurological disorders.[20] The amygdala interacts with the cortical sensory

systems in the assessment of threat and modulates reflex responses through projections to the hypothalamus and brainstem.[21] The ventromedial prefrontal cortex is connected to the amygdala, hypothalamus and periaqueductal grey and allows cortical control over the system in relation to a wider set of emotions.[21] However, experience can be disproportionately assessed as threatening, leading to adaptive brain circuit dysfunction, loss of cortical control and occurrence of functional symptoms.[22]

We aimed to review the incidence of functional ear symptoms in new referrals to the otology clinic, highlight underlying co-morbidity and present a clinical model outlining the experience-driven brain circuit dysfunction based on neuroscientific research. An understanding of these principles will significantly aid the otologist, neurologist, audiologist and other clinicians managing patients with functional ear symptoms. This is the first research article to specifically address the incidence of functional symptoms in the otology clinic.

Materials and methods

We undertook a retrospective case note review of 1000 consecutive new primary care referrals to a secondary care adult otology clinic. All new patients (aged 16 years and over) were seen by the same consultant otologist, between the dates of 1 January 2017 and 21 August 2019.

The review included data on age, sex, symptoms, examination findings, past medical history, past surgical history, life stressors, audiometry, tympanometry and imaging. Functional disorder was defined by Diagnostic and Statistical Manual of Mental Disorders-5 criteria,[1] with functional ear symptoms being identified in the absence of active physical disease, when supported by appropriate examination, audiometry, tympanometry and imaging. The data collection was retrospective, fully anonymised and non-interventional.

Results

Of 1000 patients, 576 (57.6 per cent) were female, and 424 (42.4 per cent) were male. Functional disorder was the most common primary diagnosis (346 of 1000; 34.6 per cent), followed by sensorineural hearing loss (148 of 1000; 14.8 per cent), mucosal chronic otitis media (91 of 1000; 9.1 per cent), otitis externa (70 of 1000; 7 per cent), squamous chronic otitis media (61 of 1000; 6.1 per cent), ear wax accumulation (55 of 1000; 5.5 per cent), otitis media with effusion (35 of 1000; 3.5 per cent) and otosclerosis (33 of 1000; 3.3 per cent) (Figure 1).

Functional ear symptoms presented more commonly in females (207 of 346; 60 per cent) than males (139 of 346; 40 per cent), occurring across all ages in females (16–85 years) and males (16–92 years; median ages 53 and 49 years, respectively). Symptoms reported were tinnitus (241 of 346; 69.7 per cent), imbalance (82 of 346; 23.7 per cent), otalgia (79 of 346; 22.8 per cent) and aural fullness (66 of 346; 19.1 per cent). Although only 1 ear symptom may be present (259 of 346; 75 per cent), 2 or more functional ear symptoms in the same patient were reported in 87 of 346 patients (25.1 per cent) and 3 or more symptoms were reported in 29 of 346 patients (8.3 per cent) as shown by symptom distribution in Figure 2.

Aural fullness frequently occurred together with otalgia (30 of 66; 45.5 per cent), tinnitus (39 of 66; 59.1 per cent) and imbalance (14 of 66; 21.2 per cent). Otalgia frequently occurred together with tinnitus (33 of 79; 41.8 per cent), imbalance (16 of 79; 20.3 per cent) and aural fullness (30 of 79; 38.0 per cent). In patients presenting with primary tinnitus, an additional functional ear symptom occurred in 29 per cent (70 of 241), whereas patients presenting with a functional balance disorder had additional functional ear symptoms in 46.3 per cent (38 of 82).

Figure 3 provides details of reported underlying conditions in patients with functional ear symptoms. Commonly encountered underlying conditions included sensorineural hearing loss (135 of 346; 39 per cent), emotional stress (103 of 346; 30 per cent), chronic medical illness (75 of 346; 22 per cent), chronic pain disorder (56 of 346; 16 per cent), anxiety and depression (30 of 346; 8.7 per cent), surgery (22 of 346; 6.4 per cent), noise-induced hearing loss (16 of 346; 4.6 per cent), trauma (15 of 346; 4.3 per cent), migraine (11 of 346; 3.2 per cent), and fibromyalgia (8 of 346; 2.3 per cent). Six cases had significant underlying psychiatric diagnosis, including post-traumatic stress disorder, obsessive compulsive disorder and attention deficit hyperactivity disorder.

Discussion

Approximately one-third of symptoms reported by patients in primary care and subspecialty settings remain medically unexplained after a complete evaluation.[23] Similarly, our study showed 34.6 per cent of all new referrals to the otology clinic had a functional disorder. Patients with functional disorders have structurally normal brains that have been shown to exhibit disordered function.[24] Patients experience higher rates of psychological and physical co-morbidity along with a higher incidence rate of childhood adversity.[25] In our study, co-morbidities for patients diagnosed with functional ear symptoms included stress (30 per cent), chronic illness (22 per cent), chronic pain disorder (16 per cent) and depression (8.7 per cent).

In somatosensory amplification, abnormal interactions among large-scale neural systems alter visceral-somatic perception, emotional processing and awareness, and cognitive control.[26] Amplification of neural signalling within the central nervous system induces functional symptoms and dysregulation of the sensory-motor and immune systems.[27] Deficits in access, engagement and disengagement of large-scale neurocognitive networks play a prominent role in functional disorders.[28] The circuitry of fear memory consolidation is also important, being involved in storage and retrieval of information related to experience.[29] Bringing together such concepts, we suggest a clinical model for functional ear symptoms as shown in Figure 4. We will now describe the concepts in our clinical model for functional symptoms.

Brain pathophysiology concepts

Intrinsic connectivity networks describe a set of large-scale functionally connected brain networks that can be captured in either resting state or task-based neuroimaging data.[30] Intrinsic connectivity network dysfunction forms the neural basis of functional disorders. Three important intrinsic connectivity networks are the default mode network, salience network and the central executive network, which are shown in Figure 4. The default mode network is involved in information monitoring, social cognition and initiating prediction signals. It is active in a range of internally directed cognitive processes including autobiographical memory and thinking of the future.[31] The central executive network has a role in cognitive

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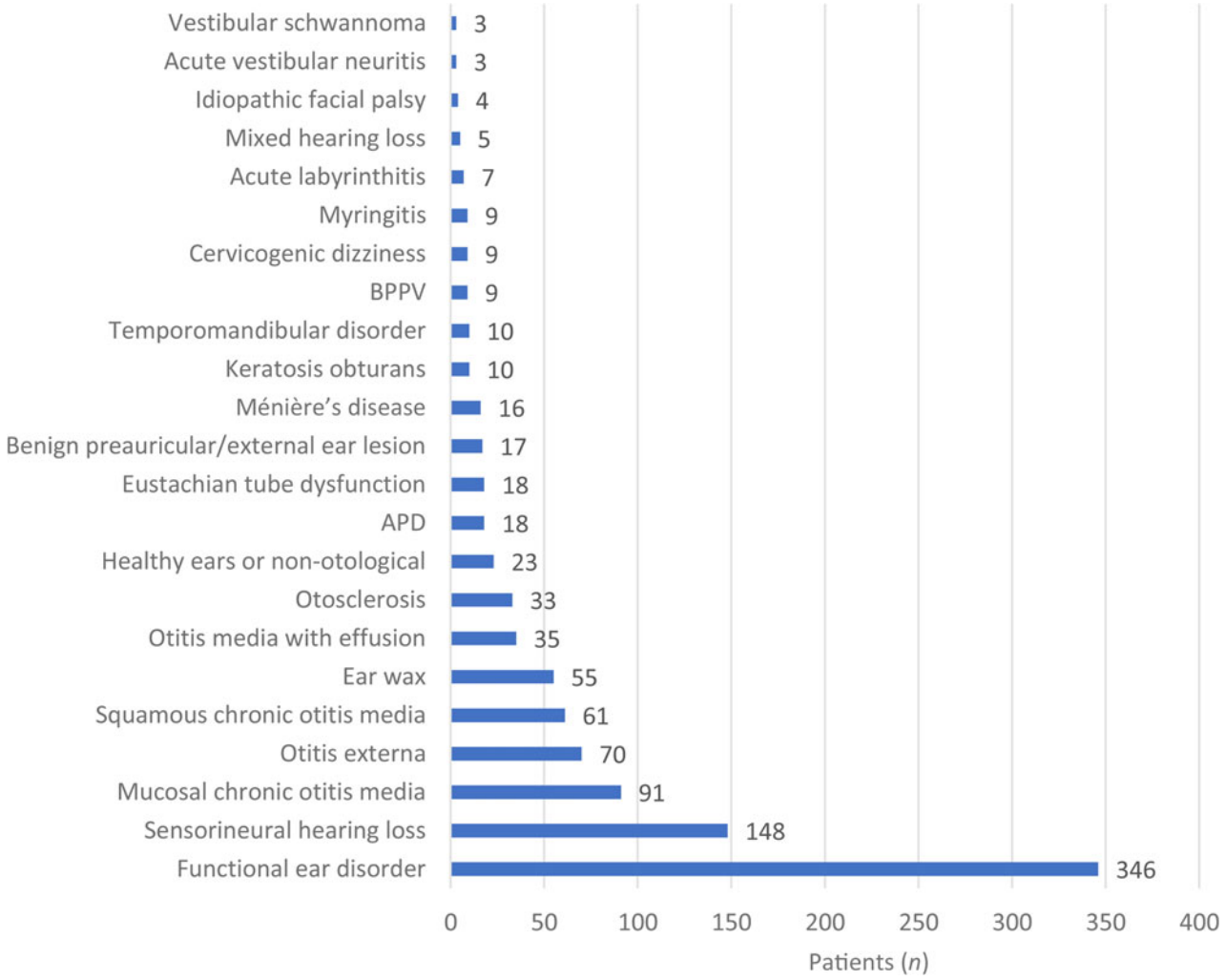

Fig. 1. Primary diagnosis for 1000 consecutive new referrals to the adult otology clinic. BPPV = benign paroxysmal positional vertigo; APD = auditory processing disorder

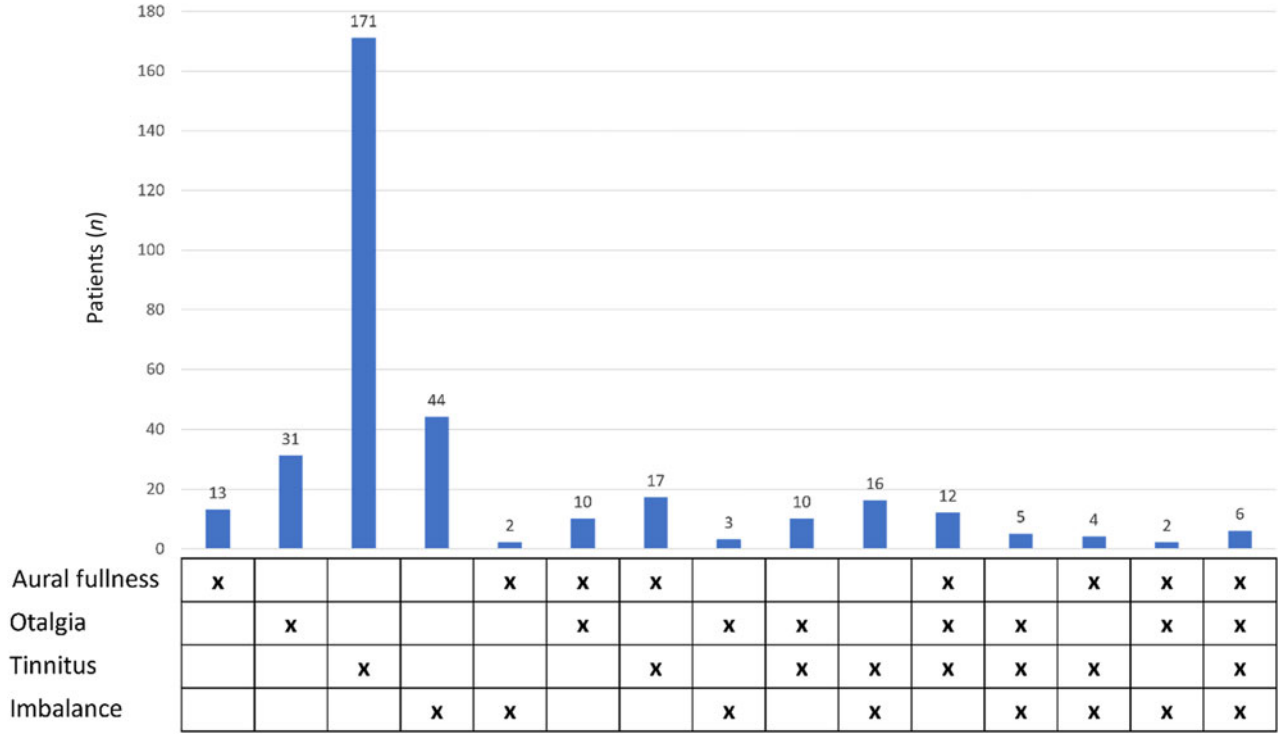

Fig. 2. Distribution of otological symptoms in patients presenting with a functional disorder. Total $n = 346$.

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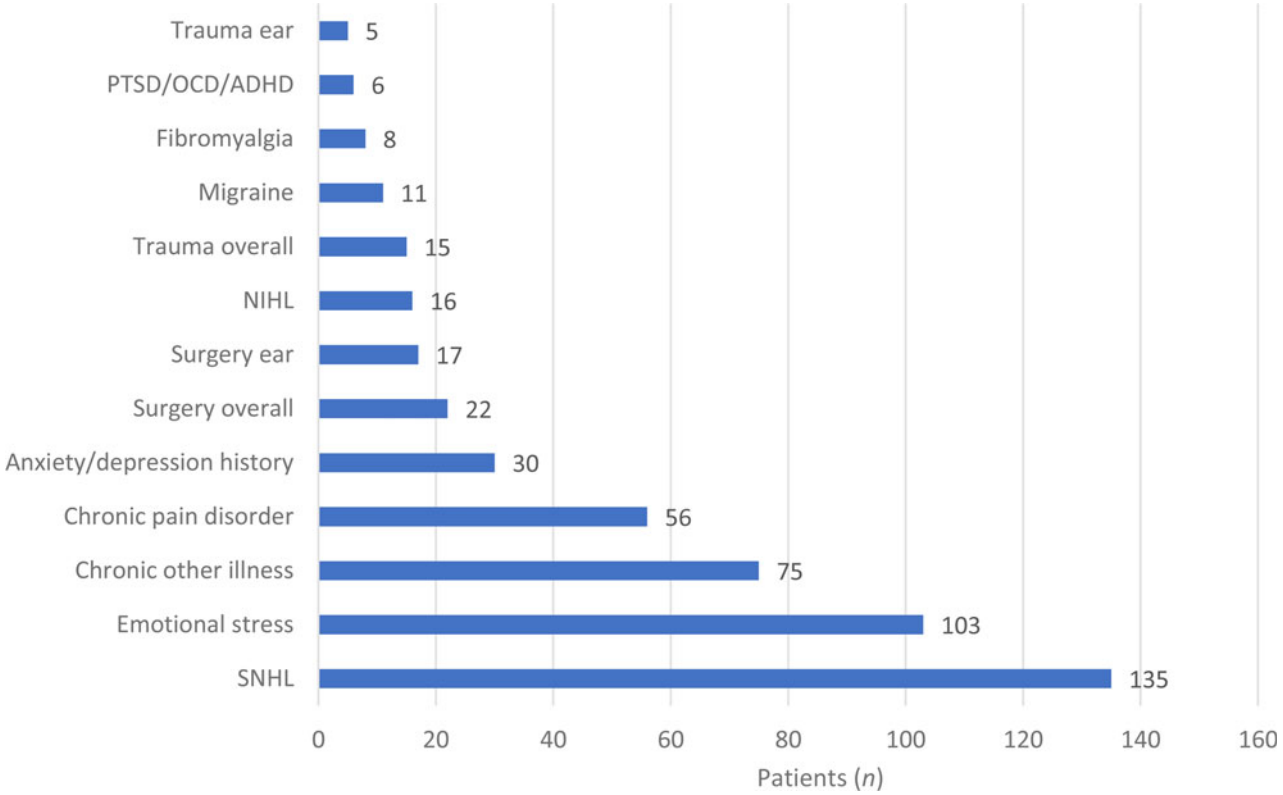

Fig. 3. Underlying conditions in 346 patients presenting with a diagnosis of functional ear disorder. PTSD = post-traumatic stress disorder; OCD = obsessive compulsive disorder; ADHD = attention deficit hyperactivity disorder; NIHL = noise-induced hearing loss; SNHL = sensorineural hearing loss

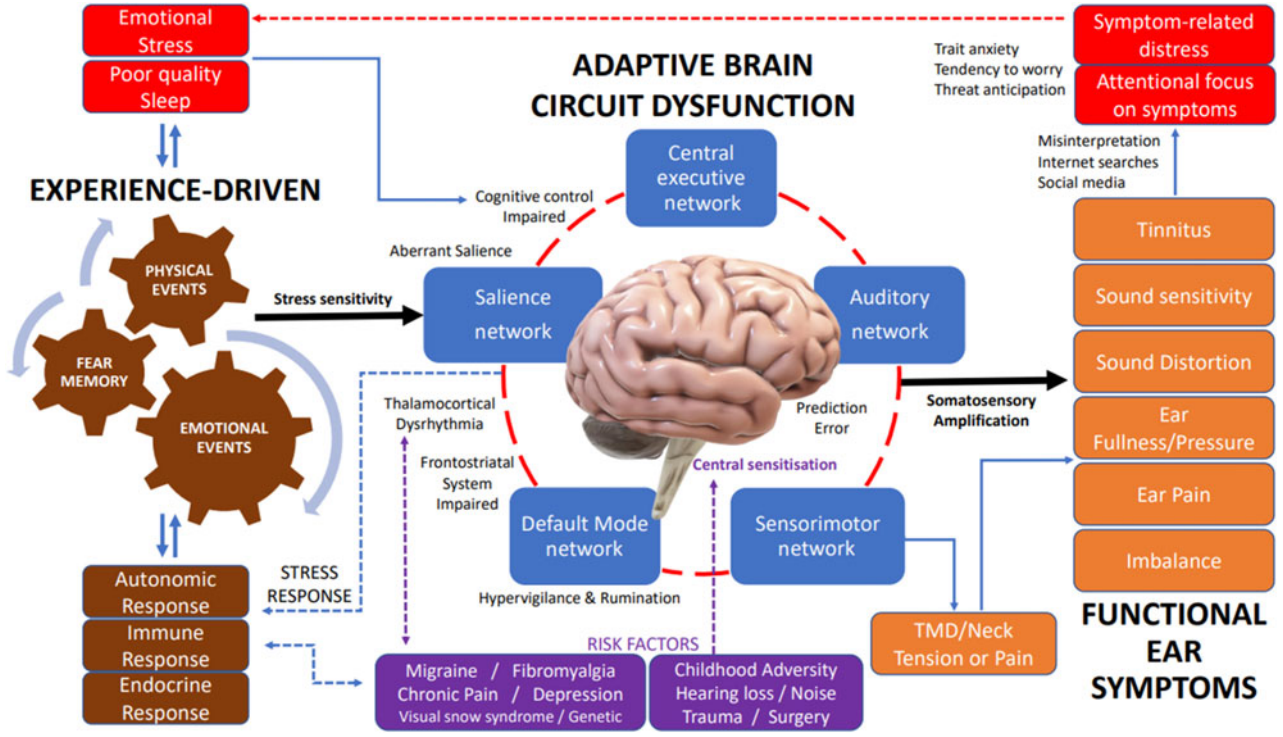

Fig. 4. Model of adaptation of brain circuitry to experience for functional ear symptoms. (1) Risk factors: central sensitisation or aberrant saliency processing can occur after childhood adversity, hearing loss, noise, or physical trauma or surgery. Migraine, fibromyalgia, chronic pain, depression and visual snow syndrome exhibit thalamocortical dysrhythmia, which hampers normal sensory information processing. Trait anxiety increases stress sensitivity. (2) Experience: physical and emotional events, associated with fear memory, generate experience and neural signalling that drives brain circuits. (3) Adaptive brain circuit dysfunction: inappropriate assignment of neural signals (aberrant salience) through the salience network disengages the central executive network (diminished cognitive control) and engages the default mode network (hypervigilance and rumination). Frontostriatal system impairment causes diminished filtering of unwanted signals that are attended and further processed. (4) Subjective perception of functional ear symptoms: aberrant neural activity and functional connectivity with amplified neural signals (somatosensory amplification) manifests as sensory signals and perception of sensory symptoms (functional ear symptoms). Stress mechanisms increase muscle tone leading to temporomandibular disorders and neck tension, which can further impact aural fullness, ear pain and functional imbalance. (5) Responses: symptom misinterpretation and focus cause emotional stress and reduced sleep which further drive the central maladaptive processes. Physiological stress responses can trigger autonomic, immune and hormonal effects. Secondary symptoms can include feeling tense, palpitations, shallow breathing, irritability, sleep disturbance and difficulty concentrating. TMD = temporomandibular disorders

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control. The salience network is important in processing sensory, emotional and cognitive information along with identifying relevant events. The triple network model of psychopathology proposes the salience network acts as a 'switch' that engages the default mode network and disengages the central executive network, leading to symptoms.[30,32]

Aberrant salience is the assignment of significance to innocuous stimuli[33] and has an adverse effect on how external and internal signals are processed. The salience network plays a crucial role in switching between brain networks involved in externally oriented attention and internally oriented mental processes.[34] The central experience that defines aberrant salience is when stimuli that ordinarily would not seem important become more significant.[35] Aberrant salience has been implicated in the pathophysiology of functional neurological disorders,[36] anxiety and mood disorders.[37]

Distress in response to tinnitus has been localised to salience network nodes such as the anterior cingulate cortex, insula and amygdala.[38] Paralimbic involvement in tinnitus patients has been suggested to indicate tinnitus distress as a state of aberrant salience, similar to other brain disorders.[37] Furthermore, attenuated activation of the central executive network and downregulated baseline connectivity between the central executive network with salience network and autobiographical memory networks has been suggested to maintain chronic tinnitus awareness.[39]

The intrinsic dynamics of thalamocortical network oscillations are crucial for early sensory processing.[40] Electrophysiological studies have shown altered thalamocortical rhythm, termed thalamocortical dysrhythmia, in a range of disorders including tinnitus, migraine, fibromyalgia and visual snow syndrome.[3,41,42] These disorders share a common temporal pattern of beta-theta and theta-gamma coupling. Self-sustaining generation of low-frequency oscillations can result in long-term cortical dysfunction.[43] The enhancement of low-frequency theta oscillations may be linked to the emergence of negative functional symptoms, while gamma upregulation could serve to induce more positive or excitatory functional symptoms.[44]

Neurology relationship

Compared with neurology clinics, our study suggests functional disorders are twice as prevalent in otology (34.6 per cent *vs* 16 per cent).[2] However, functional disorders commonly overlap. In visual snow syndrome, 52–63 per cent of patients experience tinnitus,[45,46] and the effectiveness of cognitive behavioural therapy in tinnitus has led to its utilisation for visual snow syndrome.[45] The currently accepted view is that primary headache is a result of abnormal brain function with normal brain structure.[47] There is a significant relationship between tinnitus and headache laterality and symptom interaction over time, and both disorders may be linked by common pathophysiological mechanisms.[48] It has been suggested that clocking tinnitus may be an audiological manifestation of a migraine disorder.[49] In a population-based study, the prevalence of tinnitus has been found to be significantly higher in migraine patients.[50] Similarly, isolated prolonged aural fullness has been found to improve with migraine-related lifestyle changes and prophylactic treatment.[13]

Stress relationship

Neuroimaging studies suggest amygdala prefrontal circuitry dysfunction in anxiety, creating a bias towards threat-related responses.[51] Stress and anxiety shift the balance of attention away from a task-directed mode, governed by the prefrontal cortex, to a sensory-vigilance mode, governed by the amygdala and other threat-sensitive regions.[52] In our study, 30 per cent of patients with functional ear symptoms reported increased levels of stress. Stress symptoms have been reported in 65 per cent of tinnitus patients using Lipp's inventory symptoms of stress and are related to increased tinnitus perception.[53] Other studies have shown a direct correlation between duration of tinnitus and stress severity.[54] Studies provide evidence that stressful life experiences are accompanied by autonomic and neuroendocrine changes capable of influencing immune function, thereby influencing susceptibility to infectious, autoimmune and chronic illness.[55] Childhood adversity and cumulative adverse life events can prime the stress system into a state of readiness, and even minor subsequent stressors trigger a stress response.[56]

Mental health relationship

A high incidence of anxiety and depression in primary tinnitus is described in the literature, and co-morbid psychiatric illness increases severity.[57,58] Indeed, the incidence rate of depression in people with tinnitus has been cited as being more than twice that of the national average in the US population (approximately 35 per cent *vs* approximately 15 per cent, respectively).[59] Depressive symptoms play a role in triggering and maintaining chronic tinnitus.[60] Post-traumatic stress disorder is associated with functional symptoms. A study of 468 Iraq War veterans with post-traumatic stress disorder showed higher levels of dizziness compared with veterans without post-traumatic stress disorder.[61] Vulnerability to fear and threat is evidenced by increased functional disorders with childhood adversity.[62,63] Interestingly, three patients in our study with post-traumatic stress disorder had a clear history of developing a functional disorder after a traumatic event.

Somatosensory amplification

One of the functions of fear is to enhance sensory perception for survival.[64] Somatosensory amplification describes body hypervigilance and the tendency to focus on mild body sensations, which is a key step in leading to functional symptoms (Figure 4). It relates to modern health worries, expectations of symptoms or medication side effects.[65] Somatosensory amplification has been suggested in functional pulsatile tinnitus, where there is no underlying pathology but there is deficient noise-cancelling mechanism[66] and impaired sensory gating.[67] Somatosensory catastrophising involves false attribution of bodily sensations to serious illness.[68] In our study, several patients reported increasing anxiety and severity of symptoms after internet searching. The term 'cyberchondria' has been coined to describe the unfounded escalation of concerns about common symptomology based on the review of search results and literature online.[69]

Functional otalgia and aural fullness

In our study, the symptoms of otalgia and aural fullness were reported in 22.8 per cent and 19.1 per cent of patients, respectively, who exhibited a functional disorder. Tinnitus and chronic pain have been demonstrated to share an overlapping brain network with common activation and connectivity patterns.[70] Vagal nerve stimulation has been employed to

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neuromodulate brain circuits in a variety of functional disorders, including depression, chronic pain and migraine.[71] The role of dysregulation of the autonomic nervous system and central pain pathways in the emergence of temporomandibular disorders has a growing evidence base.[27] The external ear canal has afferent vagal supply, via the auricular branch of the vagus nerve, to brain regions mediating multisensory integration. Autonomic nervous system dysfunction could have mechanistic overlap in aural fullness and otalgia because these symptoms are also associated with temporomandibular disorders.

Patient history

Functional symptoms can arise within the context of stress, pain, fatigue, injury, psychological trauma and sudden intense and overwhelming emotions.[56] In our study, 103 patients reported functional symptoms coinciding with increased stress, 14 patients during a bereavement and 23 patients during a period of significant sleep deprivation. Otological negative experience included prolonged or distressing loud noise, painful microsuction or ear syringing, ear trauma, ear surgery, childhood ear problems, and otalgia during flights or diving. Other experiences included physical illnesses, surgery and symptoms coinciding with a negative emotional reaction to starting medication because somatosensory amplification can arise from patient fear of drug side effects.[65]

Management of functional ear symptoms

Functional disorders are at the intersection of many disciplines, and treatment options are listed in Table 1. Neurologists, neuro-vestibular physiotherapists and clinical psychologists have substantial experience in managing functional disorders, and working with multidisciplinary teams of otologists and audiologists is warranted for more challenging cases. Sound therapy has been shown to alter limbic and auditory networks,[72] and neurostimulation has been increasingly explored for neuromodulating brain networks in refractory primary headache.[73]

- This is the first research article to address the incidence of functional ear symptoms in an otology clinic
- Functional neurological disorder is well established in neurology; however, it commonly presents to otology clinics
- Important co-morbidities include chronic illness, emotional stresses and adverse life experiences
- Physical or emotional experiences can be disproportionately assessed as threatening, leading to maladaptive neural signalling within brain networks
- Experience-driven neural activity, with disordered central sensory processing, forms the basis for functional symptoms
- Basic understanding of established neuroscientific principles for functional disorders are important for the ENT surgeon and help in patient education

Limitations of our study include single-centre data collection and retrospective review. Future work utilising validated questionnaires could formally assess risk factors including childhood adversity, stress and co-morbid conditions.

Conclusion

Functional disorders commonly present as the primary diagnosis to the otology clinic (34.6 per cent of new referrals). Two or more symptoms, including tinnitus, imbalance, otalgia and aural fullness often coincide (25.1 per cent), demonstrating the concept of multisensory processing at the level of the brain. Associated co-morbidity includes stress (30 per cent), chronic illness (22 per cent), chronic pain disorder (16 per cent) and depression (8.7 per cent). Physical and emotional events create experience, conditioned fear memory and can adversely enhance stress sensitivity (central sensitisation). Otological and non-otological experience drives aberrant neural activity and maladaptive brain connectivity, influencing stress responses (autonomic, endocrine and immune), memory, and cognitive and sensory processing. From this, we propose a brain-centred clinical model of adaptation of brain circuitry to experience for functional ear symptoms (Figure 4).

Stress exacerbates many chronic otological conditions, and this model may also provide insights into the chronic and recurring nature of ear symptoms seen after Ménière's disease, acute vestibular failure, autoimmune ear disease, sudden sensorineural hearing loss and ear surgery. Primary tinnitus also warrants consideration within this clinical model because it often occurs with other functional ear symptoms and has related past adverse experience, stress and co-morbidity that is additional to hearing loss and tinnitus-related distress. It is important to note that the majority of patients who present with clinically significant idiopathic sensorineural hearing loss do not report tinnitus, thus adding weight to the concept that functional factors may play a key role in symptom emergence.

Patient education, acceptance and appropriate support are crucial to avoid an otherwise repetitive cycle of clinic attendance, patient frustration, emotional distress and functional symptoms. Adjunctive use of medication may be warranted in managing associated significant psychiatric conditions, pain and migraine. Neuromodulation modalities to treat maladaptive brain circuit activity warrants further research and development to find effective long-term options.

Table 1. Treatment options for functional ear symptoms

General	Specific (as appropriate)
Reinforce patient education with information leaflet	Psychological therapies (e.g. cognitive behavioural therapy)
Regulation of sleep, diet and exercise	Audiological (e.g. hearing aid with or without sound-based therapies or neuromodulation)
Regulation of thoughts: mindfulness and meditation	Physiotherapy
Regulation of breathing: deep breathing exercises	Pain management
Regulation of screen time, internet and social media	Migraine management
Reduction in stress and workload	Treatment for hormonal imbalance
Relaxation techniques	Referral to neurology or psychiatry

Competing interests. None declared

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