Concussion & Permanent Hearing Loss

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Introduction

Concussion is defined as a traumatic brain injury that alters the way the brain functions. Symptoms are usually temporary and may include the following: dizziness, headache, nausea, loss of consciousness, confusion, tinnitus, and fatigue (Mayo Clinic).

Temporary hearing loss is rarely associated with concussion, however even permanent hearing loss has been reported. The small yet possible outcome of permanent hearing loss resulting from concussion has necessitated a review of the literature to determine validity of this relationship and to increase awareness of permanent health outcomes involved with concussion.

Question

Scoping Elements	Scoping Question
Population	Adult concussion victims.
Question	Does concussion cause permanent hearing loss?
Comparison	Is hearing loss unrelated to concussion?
Outcome	Awareness about hearing loss related to concussions.

Does concussion cause permanent hearing loss in adults with a history of concussion?

Search Terms

Scoping Question	Scoping Search Terms
Adult concussion victims.	Adults
Does concussion cause permanent hearing loss?	Concussion, closed head injury, hearing loss
Is hearing loss unrelated to concussion?	
Awareness about hearing loss related to concussions.	

Inclusion / Exclusion Criteria

Higher Priority	Lower Priority or Excluded
Humans	Not humans (e.g. animal models)
Adults (18+)	Not adults (e.g. infants, children, teens)
Permanent hearing loss caused by concussion	Duplicates from different database search results
Easily accessible & available in English	Not easily accessible through Western University libraries & not written in English

Literature Search

A systematic review of the literature was conducted. Four search terms were combined and run through the following databases: PubMed, Scopus, and EMBASE. The search yielded a total of 793 articles. The number of results from each search is outlined in the table below.

Database	Query	Search String	Total # of Hits	Results Excluded by Review of Title	Results Excluded by Review of Abstract	Results Excluded by Availability	Results Excluded by Review of Full Text	Articles for Review
PubMed	1	Concussion	2605					
	2	Closed head injury	4888					
	3	Hearing loss	28787					
	4	1 + 3	31	15	5	8	0	3
	5	2 + 3	56	32	12	6	1	5
Scopus	6	1 + 3	191	157	14	11	1	8
	7	2 + 3	428					
EMBASE	8	1 + 3	68	42	9	16	0	1
	9	2 + 3	19	12	0	1	0	6

After removing duplicates from different database search results, 11 articles were reviewed, critically appraised, and key data was extracted using the data extraction tool. The results can be viewed in the next section of this poster.

Results

Eleven articles were critically appraised for their quality using the Crowe Critical Awareness Tool (CCAT) Version 1.4. A data extraction tool was used to obtain key information from each article. This tool consisted of 8 categories: author and publication date, objective, sample size and participant characteristics, intervention, results, conclusion, implications, and a CCAT quality score. Information for each article can be seen in the table below.

Author and Date of Publication	Objective	Sample Size and participant characteristics	Intervention	Results	Conclusion	Implications	CCAT Quality Score
Bergemalm, 2001	Determine long-term objective and subjective audiological consequences of CHI.	25 adults (12 women, 13 men) aged 16-60 evaluated 7-11 yrs after CHI.	Objective testing: Ear examination, PT audiometry, tympanometry, speech audiometry, distorted speech audiometry (CAPD), acoustic reflexes, acoustic reflex decay, ABR, phase audiometry. Subjective testing: 2 questionnaires (self-assessed hearing and self-estimated quality of life).	Tinnitus and dizziness were common complaints, a number of participants exhibited high frequency hearing losses (only minor), some showed hearing loss on the side of injury, majority of the losses were unilateral, self-assessed hearing was consistent with audiometric testing, self-assessed quality of life was equal if not better than the controls.	Audiological disturbances (hearing loss, progression of loss, CAPD) were present in the majority of participants with CHI.	Higher priority should be given to early audiologic evaluation for CHI patients.	32/40= 80%
Bergemalm, 2003	Determine prevalence of progression of CHI-induced hearing loss and identify risk factors from case history that may predict progression.	43 adults (14 females, 29 males) less than 60 years of age evaluated 6 mos and 2-13 yrs after CHI.	Objective testing: Pure-tone audiometry. Subjective testing: Case history.	High prevalence of significant hearing loss (progression of ≥ 15 dB) compared to control group, no risk indicators were found in case histories, relationship between type of injury and progression (skull fracture had a higher risk of progression than contusion), relationship between initial PTA and regression and progression (the poorer the initial PTA, the worse the progression and regression), relationship between higher prevalence and increasing age.	Higher risk of progression: Poor initial PTA, increased age, temporal bone fracture. Lesser risk of progression: Patient history, sex. Time course of progression could not be determined.	Importance of audiological evaluation with CHI.	36/40= 90%
Bergemalm 2004	Determine if etiology for progressive SNHL after CHI is due to autoimmunity.	27 adults with progressive hearing loss 3-13 yrs after CHI.	Objective testing: Diagnosis of closed head injury by CT scan, SNHL determined by PT audiometry within 6 mos of injury, Western blot immunoassay technique used to detect presence of anti-HSP 70 antibodies. Subjective testing: Case history.	2 patients showed presence of anti-HSP 70 antibodies.	They could not confirm their hypothesis, however, individual cases should not be ruled out.	Pharmacological treatment to prevent progression of SNHL.	32/40= 80%
Bergemalm, 2011	Determine mechanism for progression of SNHL after CHI.	13 adults (10 males, 8 females) aged 19-80 with varying degrees of SNHL progression (mostly unilateral).	Objective testing: Otomicroscopy, audiologic evaluation (PT audiogram, tympanometry, stapedial reflexes, stapedial reflex decay), CT and MRI.	No cochlear changes were noted with the MRI or CT for the subjects with SNHL progression. No correlation between degree of SNHL progression and age, or between degree of SNHL progression and years since trauma. No relation was found between type and location of trauma and progression of SNHL after injury.	Progression most likely caused by deterioration at cellular level.	Progressive hearing loss caused by CHI cannot be determined by radiological methodology.	29/40= 73%
Griffiths, 1979	Determine incidence of otoneurological abnormalities immediately after minor head injury and presence of risk indicator for further assessment.	84 adults (mostly males) evaluated 4-10 days, 3 mos, 6 mos after injury.	Objective testing: Otological examination, vestibular assessment (positional tests), PT audiometry, caloric testing (as needed).	High incidence of hearing loss and vertigo immediately after injury. Numbers decreased 3 mos after injury indicating reversible pathology for most patients (recovery of low-frequencies).	Minor factors: How the injury was caused and the severity of impact. Important factors: Material that caused injury, site of injury (temporal > frontal), type of audiogram.	Audiovestibular testing should be part of routine assessment in all cases of head injury with concussion.	25/40= 63%
Munjal, 2010	Determine long-term audiological consequences of CHI.	290 adults with CHI evaluated 3, 6, and 12 mos after injury.	Objective testing: PT audiometry, speech audiometry, tympanometry, ABR, MLR.	Significant improvement in thresholds (at 250, 4000, 12000 Hz), speech discrimination, and tympanometric measures (middle ear compliance and physical volume) at the first follow-up, indicating recovery of low and high freq hearing and ME conductive system. Conduction time of ABR wave I absolute latency slightly decreased for first 6 mos and then stabilized. Conduction time of interpeak latency of waves III-V decreased at follow-up compared to initial visit. Conduction time of absolute latency of wave V decreased in follow-up visits. Increased amplitude and decreased latencies of waves Na and Pa were observed during first 3 mos. Left vs. right ear differences were observed, however, side of injury was not documented prior to study.	Hearing improvements were seen in the first 3 mos, followed by stabilization or deterioration. Variability was observed in the recovery of different parts of the central auditory nervous system.	Importance of long-term audiological evaluation with CHI.	29/40= 73%
Munjal, 2010	Determine audiological consequences of CHI.	290 adults with CHI were divided into 3 categories: mild, moderate, severe on the Glasgow Coma Scale.	Objective testing: PT audiometry, speech audiometry, tympanometry, acoustic reflexes, ABR, MLR.	20-30% of subjects exhibited SNHL, with high freqs being the most affected. Low incidence of conductive loss. Interpeak latencies were observed in waves III to V and I to V. Reduction in amplitudes Na and Pa (more pronounced in severe patients). MLR abnormalities (auditory cortex) were more frequent than ABR abnormalities (brainstem).	Majority of patients with CHI experienced at least mild hearing loss. Differences were mainly observed in ABR and MLR testing.	Early identification of hearing impairment is important for rehabilitation.	31/40= 78%
Nolle, 2004	Determine presence of auditory dysfunction 1 year after blunt head trauma using objective audiological tests.	31 adults (26 female, 5 male) aged 24-56 evaluated one year after head trauma.	Objective testing: PT audiogram, impedance audiometry, OAE, ABR.	PT audiograms and tympanograms were WNL, TEOAEs showed significant differences (suppression) in amplitude between patients in the linear stimulation mode (CAP), complete or partial loss of stapedial reflex was observed in majority of patients (CAP), ABR was WNL for all patients, majority of patients had lowered LDLs.	Objective audiological assessment is necessary to determine location and extent of audiological damage from head trauma.	Auditory symptoms are a minor concern after head trauma, however, they should still be investigated.	22/40= 56%
Rowlands, 2009	Determine prevalence of vestibular and otological symptoms in patients with low grade whiplash injury.	109 adults (equal # of males & females) with low grade whiplash injury evaluated within 6 mos after injury.	Objective testing: Thorough examination. No audiological testing was required. Subjective testing: Case history	No reports of symptoms of dizziness, vertigo, tinnitus, or hearing loss at time of assessment.	No otological or vestibular symptoms post injury.	Caution should be exercised when attributing these symptoms to this type of injury (regarding claims for compensation). Differential diagnosis should be completed.	32/40= 80%
Scott, 1999	Determine if patients with history of head trauma show presence of mid-freq notches in their audiometric configurations.	139 adults with notched audiograms.	Objective testing: PT audiogram. Subjective testing: Case history.	Unilateral notches were most common, notches occurred most frequently at 1000 Hz (then 2000 Hz, and then 500 Hz), and double notches were rare (no 4000 Hz notches). No relationship between notch configuration, degree of loss, laterality of notch, loss of consciousness, or locus of injury.	This study supports other research stating the relationship between mid-freq notched audiograms and head trauma.	Diagnostics.	20/40= 50%
Toh, 2010	Determine cause of unusual case of contralateral deafness after head injury in absence of temporal bone fractures.	31 year old man with left-sided head injury complaining of right-sided deafness, dizziness, and vertigo evaluated immediately after and 2 mos after head injury.	Objective testing: Pure-tone audiogram showed sensorineural deafness in his right ear, his left ear was normal, tympanogram and CT scan of right ear showed presence of fluid in his middle ear.	No base skull fractures or fistulas, and ossicular chains were intact. Follow-up 2 months later showed improvement with dizziness and vertigo, repeat audiogram was similar to previous assessment.	Most likely cause of hearing loss was labyrinthine concussion.	Patients with head injury should be warned about the possibility of permanent hearing loss.	14/40= 35%

Abbreviations: CHI- Closed Head Injury, CAPD- Central Auditory Processing Disorder, ABR- Auditory Brainstem Response, PTA- Pure Tone Average, SNHL- Sensorineural Hearing Loss, MLR- Middle Latency Response, OAE- Otoacoustic Emissions, WNL- Within Normal Limits, LDL- Loudness Discomfort Level.

Conclusions

The data extracted from the 11 articles suggests that the evidence is varied, however, generally the majority of evidence agrees that concussion can cause permanent hearing loss in adults. Audiological abnormalities (at least mild) were present in a number of patients post-CHI. Some of the studies found a higher risk of hearing loss in patients with poor initial PTA, certain configurations of audiograms, increased age, temporal injury, and depending on the material used in the injury. Some research found abnormalities in the ABR and MLR testing. Others saw recovery of audiological abnormalities within 3 months post-injury. One study found no otological or vestibular symptoms post-injury. Two of the studies ruled out morphological changes in the cochlea and autoimmunity as being the mechanisms of hearing loss post-CHI. Most of the studies concurred that objective audiological assessment is necessary to determine location and extent of audiological damage from head trauma.

The importance and implications of this research include: higher priority should be given to early and long-term audiologic evaluation for CHI patients. Early identification of hearing impairment is important for rehabilitation. Audiovestibular testing should be part of routine assessment in all cases of head injury with concussion. In the least, auditory symptoms are a minor concern after head trauma, however, they should still be investigated. Caution should be exercised when attributing these symptoms to this type of injury, therefore a differential diagnosis should always be completed.

A limitation of this review was the search terms used. Concussion refers to a specific type of traumatic brain injury; caution should be given to which terms are included in the literature search. Closed head injury and whiplash were included in the review because of their relationship to concussion and because they increased the number of search results. Further research for the topic of this review could look at specific types of traumatic brain injury and permanent hearing loss. In addition, future research could look toward creating a more standardized method of audiological evaluation for post-CHI adults.

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