DETERMINING THE DIAGNOSTIC ACCURACY OF TUNING FORK WEBER TEST AND AUDIOMETRIC WEBER TEST IN CONDUCTIVE HEARING LOSS INDIVIDUALS

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ABSTRAK

Objektif:

Ujian Weber biasanya dilakukan menggunakan garpu penala tetapi audiometer juga dapat digunakan untuk tujuan serupa. Berbanding dengan ujian Weber menggunakan garpu penala, melakukan ujian Audiometric Weber (AW) menawarkan beberapa fleksibiliti kerana pelbagai frekuensi dapat diuji dan nada yang digunakan boleh dilaras dan ditetapkan pada sesuatu tahap yang diingini tanpa masalah kemerosotan tenaga. Walaupun begitu, prestasi ujian garpu penala dan AW dibandingkan dengan audiometri nada tulen (PTA) belum pernah dikaji secara sistematik. Kami menjalankan kajian untuk mengetahui ketepatan dan kesepakatan ujian Weber menggunakan garpu penala dibandingkan dengan audiometri nada tulen. Kami juga ingin mengetahui ketepatan dan kesepakatan AW dibandingkan dengan audiometri nada tulen.

Kaedah:

Ujian Weber menggunakan garpu penala dilakukan mengikut protokol yang ditetapkan pada 256 Hz dan 512 Hz. Untuk ujian AW, alat penggetar tulang B-71 diletakkan di tengah dahi, dan frekuensi 250 Hz dan 500 Hz diuji. Hasil ujian menggunakan garpu penala dan AW kemudian dibandingkan dengan jangkaan lateralisasi dari PTA.

Keputusan:

Pada 256 Hz (atau 250 Hz), nilai ketepatan keseluruhan ujian TFW dan AW masing-masing adalah 81.1% dan 86.5%. Pada 512 Hz (atau 500 Hz), hasil ketepatan keseluruhan ujian TFW dan AW masing-masing adalah 85.1% dan 82.4%. Statistik kappa menunjukkan kesepakatan besar antara kedua ujian dan PTA (k = 0,63-0,72). Hasil ketepatan yang relatif lebih baik dicatat ketika menguji peserta dengan jurang tulang-udara yang lebih besar (81.5% -89.1%) berbanding dengan jurang tulang-udara yang lebih kecil (77.7% -88.5%).

Kesimpulan: Kedua-dua ujian AW dan TFW cukup tepat dalam menilai pesakit dengan CHL. Dianjurkan bagi ahli audiologi untuk melakukan ujian AW sederhana untuk mengesahkan audiogram yang tidak lengkap atau dipersoalkan yang biasanya dijumpai dalam praktik klinikal.

KATAKUNCI : ujian weber audiometrik, ujian weber fork tuning, kehilangan pendengaran konduktif

ABSTRACT

Objectives:

Weber test is typically conducted using a tuning fork but an audiometer can also be used for a similar purpose. Compared to the tuning fork (TF) test, performing Audiometric Weber (AW) test offers several flexibilities as multiple frequencies can be tested and the sound presentation can be fixed at one intensity level without decay issue. Nevertheless, the performance of TF and AW tests in comparison to pure tone audiometry (PTA) has not been systematically studied. Therefore, the objectives of this study were to determine the accuracy and agreement of TF test in comparison to PTA and to determine the accuracy and agreement of AW test in comparison to PTA.

Methods:

TFW test was performed according to the established protocol at 256 Hz and 512 Hz. For AW test, a B-71 bone vibrator was placed in the midline of forehead, and 250 Hz and 500 Hz frequencies were tested. The results of TFW and AW tests were then compared with the expected lateralization results.

Results: At 256 Hz (or 250 Hz), the overall accuracy values of TFW and AW tests were 81.1% and 86.5%, respectively. At 512 Hz (or 500 Hz), the overall accuracy results of TFW and AW tests were 85.1% and 82.4%, respectively. The kappa statistics revealed substantial agreements between the two tests and PTA (k = 0.63-0.72). Relatively better accuracy results were noted when testing participants with larger air-bone gaps (81.5%-89.1%) compared to those with smaller air-bone gaps (77.7%-88.5%).

Conclusion: Both AW and TFW tests are reasonably accurate in assessing patients with CHL. It is recommended for audiologists to perform the simple AW test to verify

incomplete or questionable audiograms that are commonly encountered in clinical practice.

KEYWORDS: audiometric weber test, tuning fork weber test, conductive hearing loss

CHAPTER 1:

INTRODUCTION

1. INTRODUCTION

The tests to evaluate the air conduction is relatively simpler as compare to the bone conduction tests. The air conduction can be masked with a separate hearing tests between right and left ear. This is not applicable when it comes to bone conduction, as it is technically difficult to test bone conduction as a separate unit. Despite of advance and improvement in hearing tests available, the audiograms sometimes unable to represent the true cochlear value of each ear. An ancient findings about Weber test found back in 1834, where this simple test enable one to detect especially the conductive hearing loss by lateralization of the sound to the poorer ear. A study done by Rubinstein et al proposed a Weber formula whereby the value of at least 5dB difference in between ears can produce lateralization of weber test (1).

Weber test is typically conducted using a tuning fork to detect unilateral CHL or unilateral SNHL, but an audiometer's bone transducer can also be used for a similar purpose and it is called Audiometric Weber test. The concept of Audiometric Weber (AW) is just the same as tuning fork weber (TFW), however, by performing AW test offers several flexibilities as multiple frequencies can be tested, the sound presentation can be controlled at intended intensity and frequency, no decay issue, not an operator dependant, offers consistent force on forehead surface area and lesser possibility of the sound being heard by air conduction (2, 3). The usage of bone vibrator belongs to audiometer was described by Sonnenschein in the article regarding fundamental principles of functional hearing test in the year of 1933 (3). Despite of unaccustomed to it, AW test had been done by few other researchers such as Thompson et al (4) and Markle et al (2).

The TF Weber test also has had its value as a screening test, is widely available, cheap, and easily mobilized (3). It has the sensitivity of 67% and specificity of 67.5% to detect a correct lateralization (5). However, it is very much affected by the technique of using TF, the material, the temperature and the force (5). Despite a lot of study arguing about the reliability of the TF test since years ago, however it remains being one of the most practicable clinical hearing test devices in clinic based until today & is believed by all, that TF is crucial to supplement the audiometric result.

Nevertheless, the performance of TF and AW tests in comparison to pure tone audiometry (PTA) has yet not widely been studied and there is pretty scarce literature found on this topic especially AW test.

Now that in the era of PTA is widely and universally available, it can gives a lot of information such as type of hearing loss, which ear is affected, the threshold of hearing, the configuration of hearing loss frequency and the predicted speech perception. Therefore, it is regarded that PTA is a gold standard in diagnosing hearing loss. However, TF should not be forgotten, because the value of clinical hearing test using Weber test is still relevance. The clinician should know about its accuracy, condition for optimal performance and its own limitations (5).

But besides of it being a gold standard diagnostic device, we need to beware of "false air bone gap (ABG)". This is especially involving the lower frequency where there is presence of vibrotactile (VT) activity. VT can presence as low as 25dB at 250Hz and 55dB at 500Hz (6). When assessing the air conduction threshold, the presence of VT activity can lead to the assumption of presence of residual hearing in a profound hearing loss patient. The VT also can affect the bone conduction threshold by creating an inappropriate ABG which can be misdisgnosed as CHL (7).

False ABG also can be due to harmonic distortion properties, which can appear starting at 20-30dB dB at 250Hz (8). The harmonic distortions properties, as well as resonance characteristics of several different bone vibrators can give influence to the hearing threshold. As a consequent, the bone conduction can be affected which cause a false ABG. The apparent hearing threshold can be lower than the actual threshold as a result of harmonic energies (8).

Another critical point appointed by Hood et al in his study about the importance of calibrations of both air conduction (AC) and bone conduction (BC) to get an accurate hearing threshold (9). However, we need to bear in minds about variance in the level of either AC or BC in the populations, which might be differ than the standard calibrations. These variances too can lead to false ABG. Hence, the clinical bone BC such as Weber Test can guide the clinician or audiologist towards the diagnosis (9), with the difference as low as 2.5-4dB between both ears supposedly will show lateralization (5).

Therefore, this research was meant to proof the importance of using device other than PTA as an adjunct to validify the ‘trueness’ of the ABG in showing CHL, especially involving lower frequencies.

CHAPTER 2:

STUDY PROTOCOL

2.1 STUDY PROTOCOL SUBMITTED FOR ETHICAL APPROVAL

DISSERTATION PROPOSAL

Title :DETERMINING THE DIAGNOSTIC ACCURACY OF TUNING FORK WEBER TEST AND AUDIOMETRIC WEBER TEST IN CONDUCTIVE HEARING LOSS INDIVIDUALS

Protocol number :

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LIST OF ABBREVIATIONS FREQUENTLY USED :

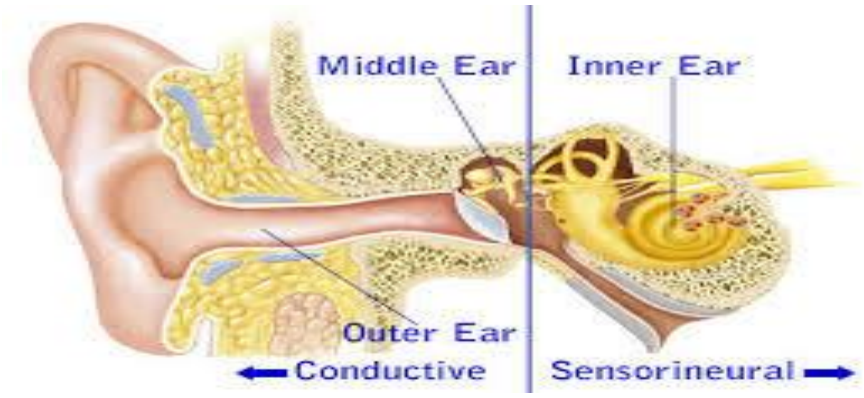
HUSM	: Hospital Universiti Sains Malaysia
ORL-HNS	: Otorhinolaryngology-Head and Neck Surgery
Hz	: Hertz
dB	: Decibel
PTA	: Pure Tone Audiometry

2.1.1 Introduction

2.1.1.1 Conductive hearing loss

To enable a person to hear a sound, it needs to be initially generated or come from a source that can cause air molecule vibrations, and the energy moving like a wave and reach a person's ear and head, to be collected by pinna, transmitted through outer ear and middle ear, transduced by inner ear, propagated via cochlear nerve and interpreted in the brain. There are 2 methods of energy being mechanically transferred, which are via wave mechanics and rigid-body dynamics. The collection and direction of airborne sound energy by the outer ear and the conversion process at the tympanic membrane lend themselves to a description using wave mechanics.

Prior to the ossicular chain, the sound energy passed via the wave mechanics. But once the airborne sound pressure has been converted into forces on the rigid bodies of the ossicular chain and its supporting structures, the mechanical transfer of sound is described in terms of classical rigid-body dynamics. Hearing loss can be divided into 3 types which are conductive, sensorineural or mixed. The conductive hearing loss can occur when there is presence of any pathology located from the outer ear till the stapediovestibular joint, and starting from this junction onwards, sensorineural hearing loss can take place. But when there is involvement of these 2 components, the hearing loss is called mixed type. The pathology that can lead to conductive hearing loss can be originated from inflammation, infection, tumour, traumatic, congenital or idiopathic. The usual common cause of conductive hearing loss are otitis media, cerumen impaction, otitis externa, tympanic membrane perforation, eustachian tube dysfunction, tympanosclerosis, ossicular chain discontinuity, foreign body ear and otosclerosis.



Picture taken from audicus.com

2.1.1.2 Tuning fork weber test

Weber test is a simple and quick clinic-based test using a tuning fork, to diagnose unilateral conductive hearing loss and unilateral sensorineural hearing loss. The test is named after Ernst Heinrich Weber who introduced this test back in 1800s, and study showed significant value as a method to diagnose hearing loss and its significant usage have been discussed and became integrated in medical curriculum as a compulsory learning material[11]. The weber tuning fork test is conducted by placing a vibrating tuning fork onto a midline osseous structure e.g. forehead, vertex or upper incisors so that this thin layer of skin or mucosal can effectively transmit the vibration onto the bony skull sagitally equal. The lateralization of sound heard by the patient will occur in one sided conductive hearing loss or bilateral conductive hearing loss with one side worse than the other. Apart from the conductive hearing loss, sensorineural hearing loss involving one side of ear also can present with weber lateralization. When the pathology involving both ear and equally at the same severity, the vibration sound by the tuning fork will be heard equally by both. In a simple word, weber lateralization will occur or can be efficiently detected when cochlear reserve is not equal in bilateral ear of a patient. In explaining this phenomenon further, unilateral or asymmetrical conductive hearing loss will be presented with a phase difference between two sounds traversing into right and left cochlea, and the bone conducted sound will lateralised towards leading phase cochlea[12]. While another study showed it is not only phase difference that play a role in mechanism of weber lateralization, the intensity difference by the bone conducted stimuli also need to be considered[13, 14]. Politzer[15] in his book explained 3 possible theories of weber test where the lateralization will go towards greater obstructive lesion; 1) by increased resonance of the external auditory canal, 2) by the reflection of the sound wave transferred via the cranial bones to the air in the external auditory canal, 3) by altered tension of the tympanic membrane and ossicles. Another theory is that the obstruction prevents the sound from escaping through the external canal and consequently 'built up' in this side, where this can happen when one is having e.g. blocked eustachian tube and can hear his or her voice/swallowing/mastication sound louder in that affected ear, where suppose when there is no blockage, this sound escape out into external ear canal outwards.

2.1.1.3 Audiometric weber test

Audiometric weber test has the same concept of tuning fork weber test as mentioned above, just it differs by the tools used to produce the vibration that is placed onto patient's forehead. Weber test by means of using audiometer bone vibrator has its own unique advantages over tuning fork. This is because the bone vibrator will maintain its intensity of output generated at the specific Hz intended and it is persistent and will not decay off[16]. Apart from that, the bone vibrator also is not operator dependent[17, 18].

2.1.2 Study Rationales

2.1.2.1 In pertaining to tuning fork, there are few hearing test that can be done using it, such as Rinne's Test, Weber Test, Bing Test, Schawabach Test, Absolute Bone Conduction Test and etc. two most common test conducted are the Rinne's and Weber. Most of the literature stating that Rinne's Test is more sensitive than Weber Test in diagnosing type of hearing loss, however the overall conclusion stated that both tests need to be done to supplement each other. This is due to the variability of the Weber Test itself being done among the examiner, such as the technique of striking the tines, the location of the tines striked, the force and counter force applied onto the osseous surface and the ambient noise where the test conducted. The tuning fork itself can be made of different material and the temperature of the tuning fork during the test need to be considered. Apart from that, Weber test is the subjective test, and it is all depends where the patient reports the lateralization. The result can be highly affected if the patient is lacking in understanding and it is important that patient is well explained prior to the test.

This study tries to eliminate all the confounding factors attributing to tuning fork Weber test (examiner factors, instrument factors, surrounding ambient noise factor and patient's factor) in the aim to generate accurate Weber result. It is then compared to the audiometric Weber, whereby the latter is expected to generate better and more stable results (correct lateralization) contributed by consistent effect of vibration produced by the bone transducer.

If there is agreement found between these two methods, then tuning fork Weber test may still be used and proof its relevance in detecting the conductive loss ear. Apart from that, the significant value of audiometric weber will also show light to the audiologist that it can be used to guide them in diagnosing conductive loss especially in uncertain cases.

2.1.2.2 The complete set of tuning fork has several different frequencies from lower to high, but the one mostly used in clinic is 512Hz. Meanwhile, in the other disciplines, the lower frequencies such as 256Hz and 128Hz are used to detect peripheral sensory neuropathy pertaining to vibration sense. In this study, the patient that has conductive hearing loss will be tested upon 512Hz tuning fork initially, then if there is no lateralization or wrong lateralization reported, the tuning fork will be down-frequency or up-frequency and the test will be repeated again. This is so, because there are cases reported of high frequency conductive hearing loss where the routine 512Hz tuning fork unable to detect leading to false negative Weber. This is similar when the conductive loss happened at much lower frequency, again the examiner might miss the lateralization which also can lead to false negative Weber.

Hence, the outcome of this study might provide better knowledge regarding Weber test, not only in handling the tuning fork itself, as it indirectly will create awareness on possibility of inaccurate Weber due to incorrect frequency of tuning fork used.

2.1.2.3 Since there is not much study done regarding audiometric Weber test, this study can provide data for future research.

2.1.2.4 When the pure tone audiometry can tell the surgeon which ear need to be operated on, it is important to have another supplementary test (in this context is the Weber test) which is consistent and proven significant to support the gold standard test, as this can augment the confidence level of the surgeon for the better patient's treatment.

2.1.2.5 This research also is important to be conducted, as it can contribute to eliminate few gaps in the existing literature, to offer a fresh perspectives and input on current otological/audiological management.

2.1.2.6 In relation to the masking dilemma whereby the exact type or degree of hearing loss unable to accurately determined, the lateralization of Weber can help to identify the better ear, therefore it can lead the audiologist to mask the correct ear.

2.1.2.7 Since tuning fork alone is not an independent tool to assess hearing loss in patient, a combination of several clinic-based tools as well as audiological audiometry are needed to generate an exact or most potential diagnosis of a patient. Therefore, it is important to have an evidence-based data on how specific and sensitive the tuning fork itself in relation to the audiometry. In the era of diagnostic and clinical audiometric assessment nowadays, the tuning fork still is a relevant otologist best friend where it is not just the art or method of using it, but it is the science of handling and using it, so that reliable examination finding is produced.

2.1.3 Objectives

2.1.3.1 General objective

i. To study the diagnostic accuracy of tuning fork weber test and audiometric weber test in unilateral and asymmetrical conductive hearing loss

2.1.3.2 Specific objectives

i. To determine the lateralization of Weber Test using tuning fork in unilateral and asymmetrical conductive hearing loss,

ii. To determine the lateralization of Weber Test using audiometric bone transducer in unilateral and asymmetrical conductive hearing loss

iii. To determine the agreement between Tuning Fork Weber Test and audiometric Weber Test, each with the PTA

iv. To determine significance of air bone gap value in lateralization of weber in Tuning Fork Test and audiometric Weber Test

2.1.4 Research hypothesis

2.1.4.1. In cases of unilateral and asymmetrical conductive hearing loss, the tuning fork weber test showed consistent result as with audiometric weber test.

2.1.4.2 In cases of unilateral or asymmetrical conductive hearing loss, weber tuning fork will lateralize to correct ear in at least 50% of patients.[4]

2.1.4.3 The lateralization of Weber test is concordance with frequency of tuning fork/bone transducer used.

2.1.5 Literature Review

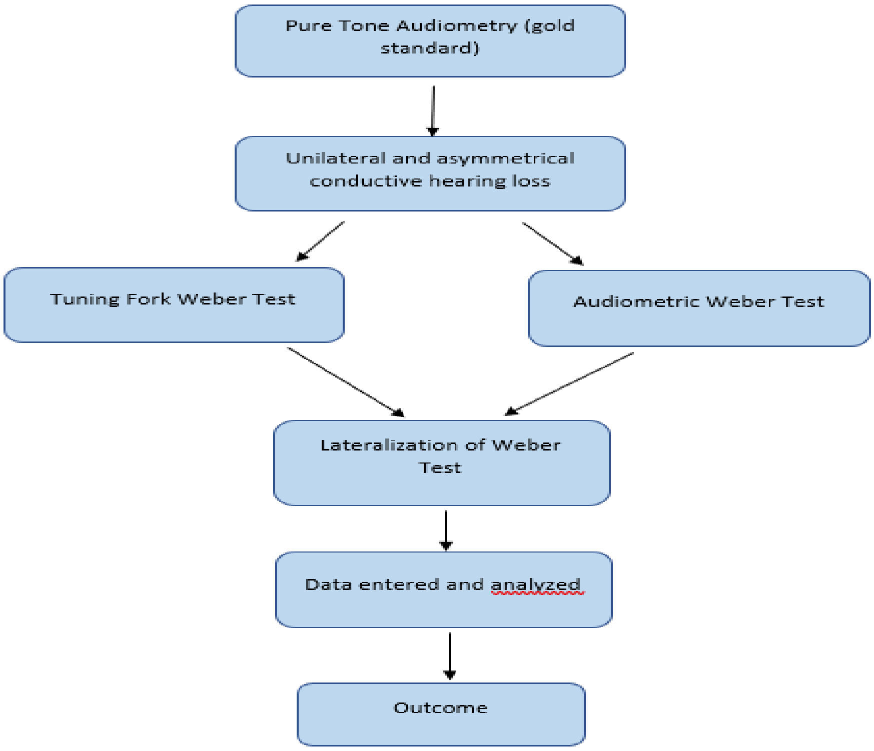
In a systematic review regarding tuning fork accuracy done by Elizabeth A. Kelly, she came to conclusion that the Weber test has poor sensitivity for identifying unilateral conductive hearing loss or sensorineural hearing loss by correct lateralization (18%-67%) and specificity ranged from 33%-97%. The Weber test was more sensitive with 512Hz forks (vs 256Hz) for detecting conductive hearing loss vs sensorineural hearing loss[1].

According to study done by Stankiewicz regarding clinical accuracy of tuning fork test, there is 50% lateralization towards poorer ear in patient with unilateral conductive hearing loss[4]. Albers and Sheehy respectively shown that with Weber test, the sound should lateralize to the poor hearing ear in the presence of conductive hearing loss and to the better hearing ear in the presence of sensorineural hearing loss [11,24]. Stankiewicz also shown in his study that Weber test is extremely variable tuning fork test and provide unreliable results, which agreed by the a study done by Thompson[4,22].

Another study done by James R. Chandler, the bone conduction sensitivity is increased in the lower frequencies with 90% or more occlusion of the external auditory canal and reaches a maximum of 14 or 15dB at 250Hz as obstruction becomes complete. He also stated that little or no change in threshold occurs above 1000Hz, even in the presence of total obstruction[21]. In the same study, he stated that the Weber test is extremely sensitive and will lateralize to one ear in the presence of minimal changes in hearing acuity as the result of partial obstruction of the external auditory canal[21].

Study by Donal M. Markle regarding usage of audiometric weber in relation to the masking, shown that the audiometric weber test has a function in evaluation of the type and extent of hearing involvements, particularly in helping in the selection of which ears require masking[23]. Based on Malaysian National ORL Registry -Hearing & Otology Related Disease/Cochlear Implant analysis of patients with hearing loss and otology related disease registered in 2010 and 2011 conducted by Dato' Dr Siti Sabzah Mohd Hashim, there were 11.7% and 14.2 % cases of conductive hearing loss patients respectively. The conductive hearing loss shows a peak in the younger age groups with gradual decrease towards adulthood and old age.

2.1.5 Conceptual Framework



2.1.6 Methods and Material

This is a cross-sectional study, conducted during period of January 2019 – December 2019. The reference population were the patients age above 12 years old, with complaint of hearing loss, referred to ORL-HNS Clinic HUSM, during January 2019 to December 2019. The inclusion criterias were:

1. Patients age above 12 years old[3]
2. Having unilateral conductive hearing loss (with ABG of at least 15 dB at any one frequency)[25]
3. Or having asymmetrical conductive hearing loss (with the difference between right and left AC thresholds of at least 15 dB at two adjacent frequencies)[25]

The exclusion criterias were :

1. Patients with mixed hearing loss

2. Patients who are unable to give appropriate behavioural response

3. Patient with canal atresia

4. Patient with sensory neuropathy

5. Patient with wound and skin diseases at head area

The sample size calculated by using the formula of sample size for a cross sectional study.

$$n = \frac{Z^2 P(1-P)}{d^2}$$

Where n is the sample size, Z is the statistic corresponding to level of confidence, whereby at 5% type 1 error ($p<0.05$) it is 1.96. Meanwhile, d value (precision) will be put at 7%. P is expected prevalence and this is obtained via the annual report of the National ORL Registry: Hearing and Otology related diseases (January 2010-December 2011), whereby the prevalence of conductive hearing loss among patients in 9 hospitals in Malaysia, in year 2011 was 12.9%[10]. Those figures integrated into the formula and calculated. Therefore, the minimum number of patients needed for this study will be of 89.

The sampling method for this study was by using non-probability- convenience or availability sampling. This method of sampling is used as previous database from National ORL Registry 2011, the prevalence of conductive hearing loss patients is 12.9% only[10], which showed small proportion of population as compared with those who are having sensorineural hearing loss. Although this may not be the representative of the whole population, but it can provide greater number of sample size. Therefore, all patient above 12 years old who attended ORL-HNS clinic HUSM with complaint of hearing loss will be screened and selected as a study subjects if meet the inclusion and exclusion criteria.

2.1.7 Instruments

Tuning fork 512Hz[4] and 256 Hz, made of steel[5], regularly calibrated[20], kept in room air[19]. Audiometer (bone oscillator)[2], with oscillation at 250 and 500Hz given, regularly calibrated together with the audiometer machine. Pure tone audiometry – Grason-Stadler 61 Clinical Audiometer. Audiometric acoustical calibrations records reviewed, latest seen on October 2018 which the calibrated based on the American National Standards Institute (ANSI) 1969. The tones delivered via insert earphones ER-3A to exclude possible ear canal collapse causing pseudo-conductive hearing loss[7]. The Impedance audiometer (Tympanometry) and a Otoscope (Welch Allyn) were used.

2.1.8 The flow of data collection

All patients aged more than 12 years old with complaint of hearing loss will be screened. Subject that fulfilled the criteria outlined as above will be interviewed by researcher after getting the informed consent. The researcher will fill up the proforma and examined the patient (at ambient noise background not more than 60dB-to increase accuracy, suppose there will be a sound level meter machine in the room, however due to unavailability of the device in current facility, a quiet room is used to do the weber test). The pure tone audiometry is the gold standard to diagnose a patient as having conductive hearing loss (particularly air-bone gap >10 dB at 500Hz), whereby it is conducted by a certified audiologist which is familiar with the instrument. The PTA is conducted in a soundproof room, and the tone is delivered via insert earphone ER-3A, and to be noted that the correction factors as recommended by the manufacturer should be strictly followed to get the correct threshold value. The insert earphones also need to be inserted at depth of 7mm from the ear entrance, to deliver the pure tones[9].

Unilateral conductive hearing loss means only 1 ear involved and in asymmetrical conductive hearing loss, both ears can have conductive hearing loss but at least both air conduction differs by 20dB, and the Weber lateralization considered correct if it goes to the poorer ear.

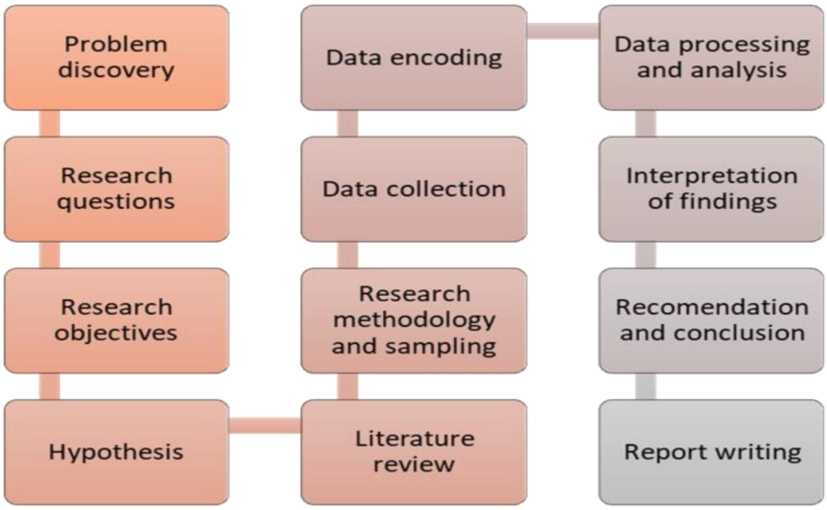
To minimize the possible bias effect, the researcher is not provided with the PTA result of the patient, therefore she has no information of which ear has the conductive hearing loss or the poorer ear. The researcher herself will conduct the tuning fork weber test as well as the audiometric weber test.

To perform a tuning fork Weber test to the patient, the same tuning fork is hold at the stem and either prong will be stricken against elbow at its upper 1/3 end. The stem of vibrating tuning fork then is placed onto midline forehead with the same pressure[6]. For the audiometric weber test, the bone oscillator will be placed onto the patient's midline forehead[8] and a pure tone at 500 Hz will be given 20 dB above the hearing threshold (20 dB SL). The lateralization of Weber test is considered correct if it is lateralized towards poorer ear. Central or equivocal or lateralization towards better ear are considered as wrong results.

In central or equivocal or lateralization to better ear results, a lower frequency of 256 Hz tuning fork and 250 Hz pure tone will be tested. The results will also be collected. The patient is expected to complete all the tests in a single visit.

The results of both tuning fork and audiometric tests will be recorded in the proforma and after completion, data will be transferred into computer for analysis purpose.

2.1.9 Study flowchart



2.1.10 Data storage

Principle investigators, co- investigators and supervisors can have access to the proforma/raw data file. After completion of the data collection, the data will be transferred into principle investigators laptop with password protected, for data analysis later. All proforma and informed consent will be kept in a file (including data in the form of soft copy), which will be kept up to 7 years after the completion of this study and shall be destroyed after that period of storage.

Structured questionnaire

- A proforma is developed for this study, used to document the patient's details and results of examination, including the graph of impedance audiometry and pure tone audiometry. This will be the source of raw data and the researcher will fill up the proforma.
- Patient will be identified using study code only, where there will be no name and identity card's number stated in the proforma.

2.1.11 Statistical analysis

Descriptive statistics and Kappa inter-rater agreement will be used to analyse listed objectives. Categorical variables will be displayed in numbers (n) and percentage, in the form of frequency tabulation and bar chart. The numerical data will be analysed for central tendency, dispersion, frequency and shape of distribution. Ninety-five percent confidence intervals were determined, and the level of significance was set at 5% ($p<0.05$). The data analysis will be done using the SPSS version 22, or any other latest version available, and biostatistician based in HUSM, Kubang Kerian will be consulted.

2.1.12 Expected results

2.1.13.1 Demographic information of participants

Epidemiological data	**Variables**	**n**
Gender	Males Females	
Ethnicity	Malay Chinese Others Indian	
Background education	Primary school Secondary school Tertiary education	
Occupations	Students Housewives Professionals Self-employed Pensioners Others Unemployed	

2.1.13.2 Classification of conductive hearing loss patient according to site and severity.

	Number of patients (n)	Percentage (%)
Unilateral CHL		
Asymmetrical CHL		
Total		

2.1.13.3 The 512Hz Tuning fork Weber test

	Number of patient (n)	Percentage (%)
Correct lateralization		
Wrong lateralization		
Total		

2.1.13.4 The 256Hz tuning fork Weber test

	Number of patient (n)	Percentage (%)
Correct lateralization		
Wrong lateralization		
Total		

2.1.13.5 The 500 Hz Audiometric Weber test at 20 dB SL

	Number of patient (n)	Percentage (%)
Correct lateralization		
Wrong lateralization		
Total		