TUNING FORK TESTS: A BASIC PRIMARY HEARING ASSESSMENT APPROACH TO IMPROVING CLINICAL EFFICIENCY

Omondi Dickens
MPH MSocSc
Principal Field Project Co-ordinator
P.O. Box 67, Kondele
Kisumu 40103
Kenya

Email: omandisda@yahoo.com

Photo: Omondi Dickens

Introduction and Historical Background

Tuning forks are made of steel, aluminium, or magnesium alloy. When vibrated they produce sound according to the set frequency. The vibrations produced can be used to assess a person's ability to hear different sound frequencies. Tuning fork tests are non-invasive, qualitative assessment procedures conducted to determine if a person has a hearing loss. The basic principle involved in the tests is that sounds can be perceived via air conduction through the middle ear and bone conduction through the skull. This provides a means of differentiating between hearing disorders located in the middle ear and those located in the sensory-neural pathways. Typically, air conduction is physiologically more sensitive because transmission of sound by air is substantially more efficient, and this advantage is lost if there is any occlusion or breakage in the conductive pathway.[1,2] Also, by the seventeenth century, it had been shown that the perception of the direction from which a sound is coming is governed by the fact that one ear is hit by the sound more intensely than the other ear. In 1827, a German physician named C.T. Tourtual and C. Wheatstone, a physicist in London, demonstrated that this phenomenon also holds true for sound conducted via the skull bones. A similar finding was demonstrated by E. H. Weber, a German anatomist and physiologist, in 1834.[3]

It is reported that the tuning fork was invented by John Shore in 1711. At first, tuning forks were made as small steel instruments consisting of a stem with two stout flat prongs. It was at the time more widely used in music, as a standard for tuning musical instruments, and in acoustic investigations. By the mid 19th century, it had been demonstrated that tuning forks can elicit 'vibration sense', which then was the acknowledged basic method of testing neural pathways. Soon afterwards, its clinical application into physiology and otology was described in greater detail by E. Schmalz, a German otologist, in 1845 and by A. Rinne, a German physician in 1855. Although the diagnostic value of tuning fork tests was initially poorly acknowledged, it gradually became more popular in clinical practice from the early twentieth century.[2] Its use has, however, diminished in most regions with the advent of audiometers and other electrical hearing test gadgets.

Indications and Use of Tuning Fork Tests

Tuning fork tests are indicated for screening of hearing loss as part of a routine clinical examination, evaluating the type of hearing loss and determining the need for referral. Use of the 512Hz and 1024Hz forks for this test is recommended. However, they should be performed, preferably, in a quiet room to minimise the effects of noise. They offer quick test methodologies which are non-invasive, easy to administer and interpret, without the need for special instrumentation. Hence, they can provide rapid clinical information on the possible diagnosis, especially where audiometers are unavailable. Additionally, they can be used to complement modern audiometric practice, such as in demonstrating aided sound field (using 4096 Hz tuning fork); ascertaining aided sensitivity at varying distances (especially for 2048 Hz tuning fork); determining impedance-integrity of the amplified system on a patient's ear (using 1024 Hz tuning fork) and balancing amplification in the hearing aid fitting process (preferably using the 512 Hz tuning fork).[2]

Their limitations in testing for hearing loss include being prone to considerable variability in technique, subjectivity in interpretation, especially in children, and accuracy due to uncontrolled sound fields. Also, they do not measure the degree of hearing loss or its effects on speech.

The most commonly used tuning fork test procedures are the Weber and Rinne tests. The Weber test is a qualitative bone conduction test that is used to assess if both ears hear equally. It is based on the principle that signal by bone lateralises to the better hearing ear or to the one with more conductive loss. The Rinne test is a qualitative test that compares perception of sounds as transmitted by air through the middle ear (AC) to that of bone conduction (BC) through the mastoid in the same ear. It is based on the principle that transmission of sound by air is more efficient than by bone conduction. Hence, a normal finding will indicate that air conduction is better than bone conduction (AC>BC). Thus, one can quickly suspect conductive hearing loss. In cases of a unilateral hearing loss, the test can be used to discriminate which of the ears has the greater bone conduction. As a screening test, it should be used complementarily with the Weber test to confirm the nature of hearing loss.

Table 1: Interpreting Results

Test	Description	Interpretation
Weber It tests if both ears hear equally	• Sound is heard centrally or in both ears equally; • Sound lateralises to better hearing ear; • Sound lateralises to poorer hearing ear;	• Normal or sensori-neural hearing loss; • Sensori-neural hearing loss; • Conductive hearing loss
Rinne It tests both AC and BC of the same ear	• Air conduction better than bone conduction (AC>BC); • Bone conduction better than air conduction (BC>AC)	• Normal or sensori-neural hearing loss; • Conductive hearing loss

Validity of Tuning Fork Tests

In terms of accuracy of tuning forks to predict hearing loss, there is obvious discrepancy in research findings in the literature. Their predictive accuracy depends on the type and severity of the hearing loss; air bone gap and differences in hearing level between both the ears. The results may, however, be subject to methodological techniques, research settings and age of participants. Some studies have shown that the values of the Rinne and Weber tests were poor predictors of mild conductive hearing loss when the air-bone gap is less than 25 dB. However, the reliability improves with an air-bone gap between 25 and 40 dB.[4,5,6] Use of a combination of Rinne, Weber, and absolute bone conduction tests, based on different tuning fork frequencies, particularly 512 Hz and 1024 Hz, was found to improve accuracy and reliability of the tests. Hence, they are recommended as initial screening tools that can be used within a primary care setting to decide whether referral to a specialist or further audiometric testing is required.[7]

On the other hand, another study has shown that there is a poor correlation between the air-bone gap and the tuning fork test results among children with OME, and concluded that the overall accuracy of the Rinne and Weber tuning fork tests, in predicting conductive hearing loss associated with OME in children, is poor.[8] In a systematic review of the tuning fork tests among the elderly, Bagai and colleagues found that the Weber and Rinne tests have low accuracy, therefore limiting their use for general screening.[9] However, more rigorous experiments based on standardised methodologies and conducted within a controlled environment are needed to confirm the screening value of tuning fork tests, particularly for the low resourced settings where audiometers and skilled staff are lacking.

Photo: Omondi Dickens

In a low resourced setting, such as Kenya, health care is based on a decentralised system where most peripheral health facilities are manned by community nurses who are not specially trained in audiology. Also, most health facilities lack special screening and diagnostic audiological equipment and the majority of the health workers are not familiar with their use either. Hence, tuning forks tests provide the most basic screening tool for hearing loss. From a service delivery point of view, increasing use of tuning fork tests is likely to increase requests for diagnostic assessment. Importantly, however, efforts to increase awareness must be accompanied by deliberate efforts to provide audiological equipment, training of staff at various levels and appropriate service delivery approaches. These would considerably improve population coverage, so that help-seeking is met with a supply of better-prepared, more responsive services.

Tuning Fork Tests

Procedure and Results

The tuning fork set available for use should ideally comprise the following frequencies:

(a) 256Hz - A low tone tuning fork, mainly vibratory, best used to deliver bone conduction tests.
(b) 512Hz - This is the most commonly used fork.
(c) 1024Hz - This frequency approximates with the Speech Reception Test (SRT) score.
(d) 2048Hz - Provides the highest test frequency with tuning forks.
(e) 4096Hz - Has a short vibrating time, usually no more than 5 or 6 seconds.[2]

Construction of the fork should be thick aluminium or stainless steel, able to produce vibratory signals of at least 50-60dBSPL of sound pressure (you may use a sound level meter to ascertain this level), with the longest possible sustained tone. The patient is instructed sit and the procedure explained adequately. Sound is produced by striking one prong of the tuning fork against a thick surface area. It is imperative that the hand holding the fork that is being struck is far enough down the handle of the tuning fork, to avoid dampening its vibration potential. The aim is to achieve uniform and solid vibration. The environment required for the tests should provide for a non-reflective site with no echoes and the back sound field levels of less than 45dB A.

It is generally recommended that tuning forks with frequencies lower than 512Hz should not be used for Rinne because the tactile vibration produced may be mistaken for sound, thereby increasing the chances of eliciting false positive responses.[4]

Rinne Test

In the Rinne test, the base of the vibrating tuning fork is held against the mastoid process, close to the auricle, to transmit sound through the mastoid bone into the inner ear. It is then held lateral to the tragus at a distance of about 2.5cm. Hold the prongs in-line with each other to reinforce their signal. Care should be taken not to touch the auricle with the stem of the fork since the tactile sensation by the auricle may be confused for sound by the patient. This is repeated alternately to allow time for the patient to judge the sounds. The patient is then asked to determine which sound is louder, the sound heard through the bone or through the air.

Weber Test

A second hearing test using a tuning fork is the Weber test. For this test, the stem or handle of the vibrating tuning fork is placed on the midline of the forehead. The patient is then asked to identify which ear hears the sound created by the vibrations. Tuning forks of different sizes produce different frequencies of vibrations and can be used to establish the range of hearing for an individual patient.

Conclusion

Despite the apparent declining value of clinical applications and questions over their accuracy, tuning forks still complement audiological tools of measurements. They offer rapid test methodologies which are none invasive, easy to administer, interpret and do not require special instrumentation. Hence, they provide a valuable alternative hearing assessment tool, particularly where audiometers are unavailable.

In terms of service delivery, the tuning fork tests may improve clinical efficiency in a busy clinic or ward, as a rapid test which is easy to use even by a non-specialist, particularly in poorly resourced settings.

In low resourced situations, especially with a decentralised health system, where most peripheral health facilities are manned by community nurses who are not specially trained in audiology, the tuning fork tests still remain the most basic screening method for hearing loss.

High disease burdens and population coverage by services remain a critical concern in such settings. Simultaneously, there is a substantial gap between what could be achieved and what is actually being achieved in terms of health improvement in low- and middle-income countries. Therefore, simple cost-effective interventions to address common diagnostic needs are essential to augment care.

With widespread use of the tuning fork tests, it is likely that there will be increasing requests for diagnostic audiological assessment. Importantly, however, efforts to improve the demand side must be accompanied by strong health systems and service reform, so that help-seeking is met with a supply of better-prepared, more responsive services.

References

1. History of the tuning fork II: Evolution of the classical experiments by Weber, Rinne and Schwabach. Feldmann H. *Laryngo-rhino-otologie.* 1997; **76**(5): 318-26. (Abstract)
2. The Lost Art of Tuning Fork Testing. Chartrand MS (2003b). Colorado City, CO: *DigiCare Hearing Research & Rehabilitation. Source:* http://www.digicarehearing.com/im-here-to-learn-more/our-library/for-hearing-health-professionals/item/24-the-lost-art-of-tuning-fork-testing-in-dispensing-practice. Accessed on 30-03-2011.
3. Early days of the tuning fork. Pearce JM. *J Neurol Neurosurg Psychiatry.* 1998; **65**(5): 728, 723
4. The Rinne test for conductive deafness: A critical reappraisal. Chole RA, Cook GB. *Arch Otolaryngol Head Neck Surg.* 1988; **114**(4): 399-403
5. C1-tuning fork tests in school-aged children. Haapaniemi JJ, Suonpää JT, Salmivalli AJ, Virolainen ES. *Auris Nasus Larynx.* 1996; **23**: 26-32.
6. Clinical utility of the 512-Hz Rinne tuning fork test. Burkey JM. Lippy WH. Schuring AG. Rizer, Franklin M. *American Journal of Otology.* 1998; **19**(1): 59-62.
7. Combined tuning fork tests in hearing loss: explorative clinical study of the patterns. Vikram KB, Naseeruddin K. *J Otolaryngol.* 2004; **33**(4): 227-234.
8. Accuracy of the Weber and Rinne tuning fork tests in evaluation of children with otitis media with effusion. Behn A, Westerberg BD, Zhang H, Riding KH, Ludemann JP, Kozak FK. *J Otolaryngol.* 2007; **36**(4): 197-202.
9. Does this patient have hearing impairment? Bagai A, Thavendiranathan P, Detsky AS. *JAMA.* 2006; **295**(4): 416-428.

❑