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Clinical Utility of the 512-Hz Rinne Tuning Fork Test

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Objective: This study aimed to examine the reliability of the 512-Hz Rinne tuning fork test to detect conductive hearing losses. The effects of tester experience, the use of masking, and the interpretation of equivocal (+/-) Rinne results on test reliability also were examined.
Study Design: Retrospective.
Setting: Private otology practice.
Patients: 1,000 adult patients (2,000 ears) seen for their initial otologic evaluation.
Interventions: Diagnostic.
Main Outcome Measure: Sensitivity of the 512-Hz Rinne tuning fork test was assessed by comparing tuning fork results with the pure-tone average air–bone gap.
Results: Results showed the 512-Hz Rinne tuning fork test could be very effective at detecting conductive hearing losses when performed by an experienced tester and when masking was used. Sensitivity was lower when masking was not used and lowest when the Rinne was performed by a less-experienced tester. Sensitivity for all groups was improved by interpreting equivocal results as indicating a conductive loss.
Conclusions: Despite reports of poor reliability, the 512-Hz Rinne tuning fork test can be an important tool in an otology practice for the detection of conductive hearing losses and for confirming audiometric findings. In primary care settings, the Rinne would be most effective as part of a screening program for conductive hearing losses, but not as the sole indicator for referral. **Key Words:** Rinne—Tuning fork—Hearing loss.
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The Rinne tuning fork test was first described by Dr. Adolf Rinne in 1855 (1). Since that time, the test has evolved to become the most widely used tuning fork test (2). Specialists use the Rinne tuning fork test to detect and help diagnose conductive hearing losses. Nonspecialists use the test as an indicator of when otologic referral is indicated.

Simplicity is the major strength of the Rinne tuning fork test. The only equipment needed is a tuning fork and a relatively quiet room. A vibrating tuning fork is held with the tines near the external auditory canal and then the loudness compared with the base of the stem pressed against the mastoid. If the sound is perceived louder by bone conduction (mastoid placement), then a conductive hearing loss is indicated. If the sound is perceived louder by air conduction (near the external auditory canal), then a conductive loss is not indicated.

There had been a perception that the Rinne test reliably would indicate a conductive hearing loss beyond a certain air–bone gap and would not indicate a conductive loss below that point. The consensus was that the Rinne correctly would detect conductive hearing losses of 20 dB or greater (3). However, the reported conductive loss required for detection by Rinne ranged from 15 to 40 dB (4–6). As sensitivity and specificity measures were applied in the 1980s, Rinne's reliability was reported to be less than believed previously (7–9). Each study found the Rinne test to be poor at detecting small air–bone gaps (low sensitivity). The sensitivity then increased gradually as the size of the gap increased. These studies reported the Rinne was unlikely to indicate a conductive loss when there was none (high specificity), but the test could miss small or moderate conductive losses, making it unsuitable as a screening test.

The purpose of this study was to evaluate a larger group of patients with the 512-Hz Rinne tuning fork test than has been described previously. Aside from adding to the overall knowledge about the Rinne test, the larger sample examined here allows more detailed analysis. Specific goals for this study include:

1. Re-evaluating the reliability of the Rinne tuning fork test.
2. Examining the effects of experience on test reliability.
3. Determining how to interpret equivocal Rinne results.
4. Examining the effects of masking on test reliability.
5. Addressing why the Rinne test has continued to be popular as a screening and diagnostic procedure despite reports of poor reliability.
6. Evaluating the utility of the Rinne tuning fork test for otology and primary care settings.

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METHOD

Clinical records from the years 1994 and 1995 were examined alphabetically to find 1,000 adult patients (2,000 ears) who were seen for the first time. This number represents approximately 20% of the new patients seen over this period. Only new patients to the office were included to eliminate any bias from past visits or test results. Routine evaluation of new patients included a patient history, otologic–microscopic examination, Rinne and Weber tuning fork testing, and audiometric and impedance testing. Rinne tuning fork testing was performed after the patient history and otologic examination but before audiometric and impedance testing.

Rinne testing was performed in an examining room using a 512-Hz tuning fork. The test was performed using the loudness comparison method. A vibrating tuning fork was held perpendicular to the external auditory canal approximately 1 in (2.5 cm) from the meatus, consistent with the 2 to 2.5 cm recommended by others (9,10). The base of the fork then was placed firmly against the mastoid. The patient was asked if the sound was louder in the front or in the back. The test then was repeated in the same manner. If the tuning fork in each case was louder by bone conduction (tuning fork in the back on the mastoid), then the test was considered to be Rinne negative, indicating a conductive loss. If the tuning fork in each case was louder by air conduction (tuning fork in front by the meatus), then the test was considered Rinne positive, indicating there was not a conductive loss. The test was considered equivocal if the patient alternated between Rinne-positive and Rinne-negative responses. One physician used a Maico ME-4 masker to present 500-Hz narrowband noise in the nontest ear when there was any indication of an asymmetric hearing loss. The other six physicians did not mask the nontest ear during Rinne tuning fork testing.

Audiometric testing then was performed in Industrial Acoustics Company double-walled sound rooms. Hearing evaluations consisted of pure-tone air and bone conduction, speech reception threshold, and word recognition score testing. Rinne results were compared to the pure-tone average (PTA) air–bone gap to calculate sensitivity and specificity. For sensitivity and specificity calculations, PTA air–bone gaps of 10 dB or greater were considered to indicate a conductive hearing loss, whereas PTA air–bone gaps less than 10 dB were not considered conductive. The effect of experience and masking also was evaluated.

RESULTS

A conductive hearing loss was found in 201 (10%) of the 2,000 ears examined. The mean conductive hearing loss was 23.1 dB (standard deviation = 9.7 dB). The range was 10 to 51.7 dB. The conductive losses were attributed to otitis media in 42% of the cases, otosclerosis in 37% of the cases, eardrum perforations in 11% of the cases, and other causes in the remaining 10% of the cases.

The 512-Hz Rinne test correctly gave a positive result in the majority (96.6%) of the 1,799 cases in which there was no conductive loss. The high number of positive Rinne test results for these cases indicates the test is unlikely to indicate a conductive hearing loss when there is none (high specificity). The 512-Hz Rinne tuning fork test correctly gave a negative result in 73.1% of the 201 cases in which there was a 10 dB or greater conductive hearing loss (sensitivity). Rinne's sensitivity increased to 80.1% when equivocal results were included as negative test results. Sensitivity of the Rinne test was greater for large air–bone gaps than for small gaps. Table 1 lists the sensitivity of the 512-Hz Rinne tuning fork test as a function of the PTA air–bone gap.

Because performing the Rinne tuning fork test after the otologic examination created the potential for bias, results from patients diagnosed with otitis media (visible pathology) were compared to those of patients with otosclerosis (normal otologic examination). If the otologic examination biased reported Rinne test results, then the sensitivity of the test for patients with otitis media should have been greater than for patients with otosclerosis. It was not. In fact, the sensitivity for patients with otosclerosis (92%) was found to be higher than for patients with otitis media (68%). However, the average conductive hearing loss for patients with otosclerosis (27 dB) was greater than for patients with otitis media (21 dB), biasing the results in favor of the patients with otosclerosis.

Table 2 lists the effects of masking and experience on the ability of the 512-Hz Rinne tuning fork test to detect conductive hearing losses of 10 to 19 dB, 20 to 29 dB, and 30 dB and greater. Table 3 lists the effects of masking and experience on the ability of the Rinne test to detect conductive hearing losses of 10 dB or more, 20 dB or more, and 30 dB or more. Overall sensitivity of Rinne test results for experienced otologists was found to be highest when masking was used. The mean sensitivity of the unmasked Rinne was higher for experienced physicians than for otology fellows. Test specificity was not effected by either masking or experience.

DISCUSSION

Sensitivity of the 512-Hz Rinne tuning fork test to detect conductive hearing losses was found to vary greatly depending on the experience of the tester and whether masking was used. The test was most sensitive when performed by an experienced otologist using masking (Tables 2 and 3). Sensitivity was the worst for less-experienced testers (otology fellows) not using masking. Results for experienced otologists not using masking fell between these two extremes. Unmasked Rinne test results seemed to agree with several other studies reporting that the Rinne tuning fork test was not as sensitive as had previously been believed (7–9). The masked Rinne test

TABLE 1. *Sensitivity of the 512-Hz Rinne tuning fork test to detect conductive hearing losses when equivocal (+/–) results are excluded and included*

Air–bone gap	Equivocal results excluded		Equivocal results included	
	n	%	n	%
10–19 dB	41/83	49.4	49/83	59.0
20–29 dB	58/66	87.9	62/66	93.9
≥30 dB	48/52	92.3	50/52	96.2

TABLE 2. *Sensitivity of the 512-Hz Rinne tuning fork test without and with equivocal responses to detect conductive hearing losses for experienced otologists using masking, experienced otologists not using masking, and otology fellows not using masking*

Air–bone gap	Otol: masked (%)		Otol: unmasked (%)		Fel: unmasked (%)	
	w/o +/–	w +/–	w/o +/–	w +/–	w/o +/–	w +/–
10–19 dB	65.9	70.5	39.1	52.2	18.7	37.5
20–29 dB	95.2	100.0	84.2	89.5	40.0	60.0
≥30 dB	100.0	100.0	100.0	100.0	66.7	83.3

Otol: masked, experienced otologists using masking; otol: unmasked, experienced otologists not using masking; fel: unmasked, otology fellows not using masking; w/o, without; w, with.

results from this study agreed with statements that the Rinne can be very sensitive when performed properly (11). These results indicate that although the 512-Hz Rinne tuning fork test can be a very sensitive instrument for the detection of conductive hearing losses, this sensitivity may not be obtained by everyone who performs it.

Other reports examining the sensitivity and specificity of the Rinne tuning fork test found no significant difference between including or excluding equivocal results (8,9). Because equivocal responses comprised only 1% of the results for nonconductive hearing loss ears in this study, including equivocal responses did not significantly effect specificity. In contrast, because equivocal Rinne test results comprised 7% of the results for the conductive hearing loss ears, including equivocal results improved sensitivity. The overall sensitivity of detecting conductive hearing losses of 10 dB or greater was increased from 73.1% to 80.1% by including equivocal results. Rinne's sensitivity of detecting conductive hearing losses of 20 dB or greater was increased to 94.9% by adding equivocal responses. In addition to the overall sensitivity of the Rinne being improved by including equivocal responses, the sensitivity was improved under all three conditions: 1) experienced otologist using masking; 2) experienced otologist not using masking; and 3) otology fellow not using masking. However, it must be recognized that the chance of any individual patient who had an equivocal Rinne test result also having a conductive loss was only 42% in our study. This number would be higher in a population having more conductive hearing losses and lower in a population having fewer conductive losses. Because including equivocal results improved the sensitivity of the Rinne tuning fork test without hurting specificity, we would recommend considering an equivocal Rinne test result the same as a negative test result when used for screening purposes.

This study shows two reasons why the Rinne tuning fork test continues to be popular as a diagnostic and screening procedure for the detection of conductive hearing loss. First, the study showed that the Rinne can be very accurate (correctly distinguishing between sensorineural and conductive losses in 96% of the cases) when performed by an experienced physician using masking. Second, the study showed that the overall accuracy can remain high (91% for clinical fellows not using masking) even when the Rinne was failing to detect conductive losses. This apparent accuracy was largely because the majority of patients did not have conductive hearing losses. If the ears with obvious conductive pathology had been excluded (Rinne not performed) as was advocated (9), then the accuracy would appear even higher because there would be fewer conductive losses to miss. Finally, we believe the availability of tuning forks and the simplicity of test procedures also are responsible for the continued use and popularity of the Rinne tuning fork test.

In an otology practice in which audiometric and impedance testing routinely are used to differentiate between conductive and nonconductive hearing losses, the Rinne tuning fork test remains highly useful. One strength of the Rinne test is that it rarely indicates a conductive loss when there is none. In only 2% of the ears did the Rinne indicate a conductive hearing loss in the presence of normal hearing or a sensorineural hearing loss. If equivocal responses were included, the Rinne mistakenly indicated a conductive hearing loss in only 3% of the ears. These findings were constant regardless of masking or tester experience. Another strength of the

TABLE 3. *Sensitivity of the 512-Hz Rinne tuning fork test without (w/o +/–) and with (w +/–) equivocal responses to detect conductive hearing losses greater than or equal to 10, 20, and 30 dB for experienced otologists using masking, experienced otologists not using masking, and otology fellows not using masking*

Air–bone gap	Otol: masked		Otol: unmasked		Fel: unmasked	
	w/o +/–	w +/–	w/o +/–	w +/–	w/o +/–	w +/–
≥10 dB	85.7	89.1	65.3	73.5	39.4	57.6
≥20 dB	97.3	100.0	88.5	92.3	58.8	76.5
≥30 dB	100.0	100.0	100.0	100.0	66.7	83.3

Otol: masked, experienced otologists using masking; otol: unmasked, experienced otologists not using masking; fel: unmasked, otology fellows not using masking; w/o, without; w, with.

512-Hz Rinne test is that it can be very sensitive at detecting conductive hearing losses when the tester is experienced, masking is used, and equivocal responses are interpreted as indicating a conductive hearing loss. Under these conditions, the Rinne test detected 100% of conductive hearing losses 20 dB or greater and 89.1% of conductive losses 10 dB or greater. The ability to detect a conductive hearing loss would have been increased slightly to 92.4% if Weber tuning fork results were combined with the Rinne test, as is often done. These results show that the 512-Hz Rinne tuning fork test can be a reliable indicator of conductive hearing loss and confirmation of audiometric results.

Results from this study indicate that care must be taken in primary care settings where the Rinne tuning fork test is used as a screening measure to detect conductive hearing losses. Because masking rarely is used outside an otology or audiology practice, we would not expect the sensitivity to surpass that of experienced otologists not using masking. This would mean that 26.5% of conductive hearing losses of 10 dB or more would be missed. More conductive hearing losses might be missed if the sensitivity of the Rinne test in primary care settings is closer to that seen for otology fellows. Fortunately, the Rinne tuning fork test rarely is used as the sole screening method for the detection of conductive hearing losses. Ruckenstein (12) recently has stressed the importance of combining the findings from the patient history, otologic examination, and tuning fork results (both Weber and Rinne) to determine when otologic referral is indicated. In addition to these recommendations, we also would recommend the use of a hand-held hearing screener. This device has the simplicity of the Rinne test and additionally would detect sensorineural hearing losses. We think the 512-Hz Rinne tuning fork test is a very important part of a screening program for the detection of conductive hearing loss, but that a positive Rinne test result should not negate the need for otologic referral if the patient history or Weber test result indicates a problem.

CONCLUSIONS

The 512-Hz Rinne tuning fork test can be a very effective tool for the detection of conductive hearing losses. The Rinne is most sensitive when performed by an experienced tester and when masking is used. Sensitivity of the Rinne test is further improved by interpreting equivocal results as indicating a conductive loss. In an otology practice, the Rinne test is an important tool for detecting conductive hearing losses and as a validation of audiometric results. In primary care settings, the Rinne test is best used as part of a screening program for conductive hearing losses but not as the sole indicator for otologic referral.

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