THE AMERICAN JOURNAL OF OTOLOGY/VOLUME 9, NUMBER 1 *January 1988*

TUNING FORK TESTS: FORGOTTEN ART

*Tawfik F. Girgis, M.D., F.A.C.S.**
and
George E. Shambaugh, Jr., M.D., F.A.C.S.†

ABSTRACT

Four examples are cited in which tuning fork tests helped in proper selection of patients for surgery, after audiometric air and bone tests were equivocal or gave the wrong diagnostic and prognostic indication.

Many younger otolaryngologists and residents in training are not taught to use tuning forks to assist in evaluation of hearing impairments. Furthermore, with the new more sophisticated audiologic tests, use of tuning forks is frequently forgotten. Experience in the use of tuning forks might have prevented an error in surgical indication in a recent malpractice suit in which the senior author (G.E.S.) was required to testify.

Recent otolaryngologic literature includes two articles with opposing views on the value of tuning fork tests. Stankiewicz and Nowry in 1974[1] question the diagnostic accuracy of tuning fork tests. Sheehy, Gardner, and Hambly in 1971[2] recommend routine use of tuning forks to check the accuracy of audiometric assessment.

HISTORIC BACKGROUND

Giovanni Filippo Ingrassia (1510–1580), the discoverer of the oval and round windows, first described a tuning fork for tuning a musical instrument. In 1825, Ernest Heinrich Weber and his brother Wilhelm published their experiments on air waves and transmission of sound. They described how a vibrating tuning fork placed on the vertex is heard in the poorer hearing ear in a conductive defect and in the better hearing ear in a nerve type of loss. In 1855, Heinrich Adolf Rinne[3] compared air with bone conduction and concluded that with normal hearing the tuning fork is heard longer by air than by bone. The Rinne test has become the most useful of the tuning fork tests in our experience. In 1885, Dagobert Schwabach[4] stated that prolongation of bone conduction hearing in an impaired ear indicates a conductive loss.

The senior author (G.E.S.) completed his residency in 1932 and joined his father in a practice heavily skewed toward otology. At that time, the newly designed Western Electric #1 Audiometer began to be available in teaching clinics and in a few private offices. Audiograms were performed by the otologic physician, testing pure tones by air from 32 Hz to 16,000 Hz and by bone with a bone conduction receiver pressed against the mastoid process. In all patients, the audiometric results were supplemented by the standard tuning fork test of Weber, Rinne, and Schwabach, performed with the 128- or 256-Hz steel tuning fork. Upper and lower tone limits were tested with a 32-Hz and a 4,096-Hz tuning fork. The upper tone limit was established by a monochord.

Under the tutelage of his father, the senior author became adept at differentiating conductive from sensorineural hearing losses and also cochlear hydrops from cochlear otospongiosis or other nerve type losses by testing for diplacusis. Diplacusis is easily and quickly tested by holding the 256-Hz tuning fork at such a distance from either ear to approximate the same intensity and then by asking the patient to identify and describe any pitch difference. Diplacusis is a valuable but often neglected, diagnostic test for endolymphatic hydrops.

In 1938, the senior author became Lempert's first pupil for the one-stage fenestration operation for otosclerosis. The tuning fork tests, especially the Rinne test, were an important aid in selection

Reprint requests to: Dr. Girgis, 40 South Clay Street, Hinsdale, Illinois 60521
*Assistant Professor of Otolaryngology, Head and Neck Surgery, Northwestern University Medical School, Evanston, Illinois
†Professor and Chairman Emeritus of Otolaryngology, Northwestern University Medical School, Evanston, Illinois

of patients for this operation. As a result, in over 10,000 operations for otosclerosis between 1938 and 1983 the senior author was able to avoid any unnecessary operation because of an error in diagnosis and prognosis. In contrast today, occasional patients are encountered who were subjected to unnecessary surgery because of failure to use tuning forks to rule out a "dead ear," an unsuspected hydrops, or a sensorineural loss incorrectly diagnosed as a conductive loss by the pure tone air and bone audiogram.

TECHNIQUE OF ROUTINE TUNING FORK TESTS

We routinely supplement air and bone audiometry and tympanometry with tuning forks to evaluate hearing impairments. After preliminary inspection of the tympanic membrane and osseous meatus, the following tuning fork tests require no more than 5 or at most 10 minutes of the physician's time.

Upper and lower tone limits are established with the 64-Hz and 4,096-Hz tuning forks held

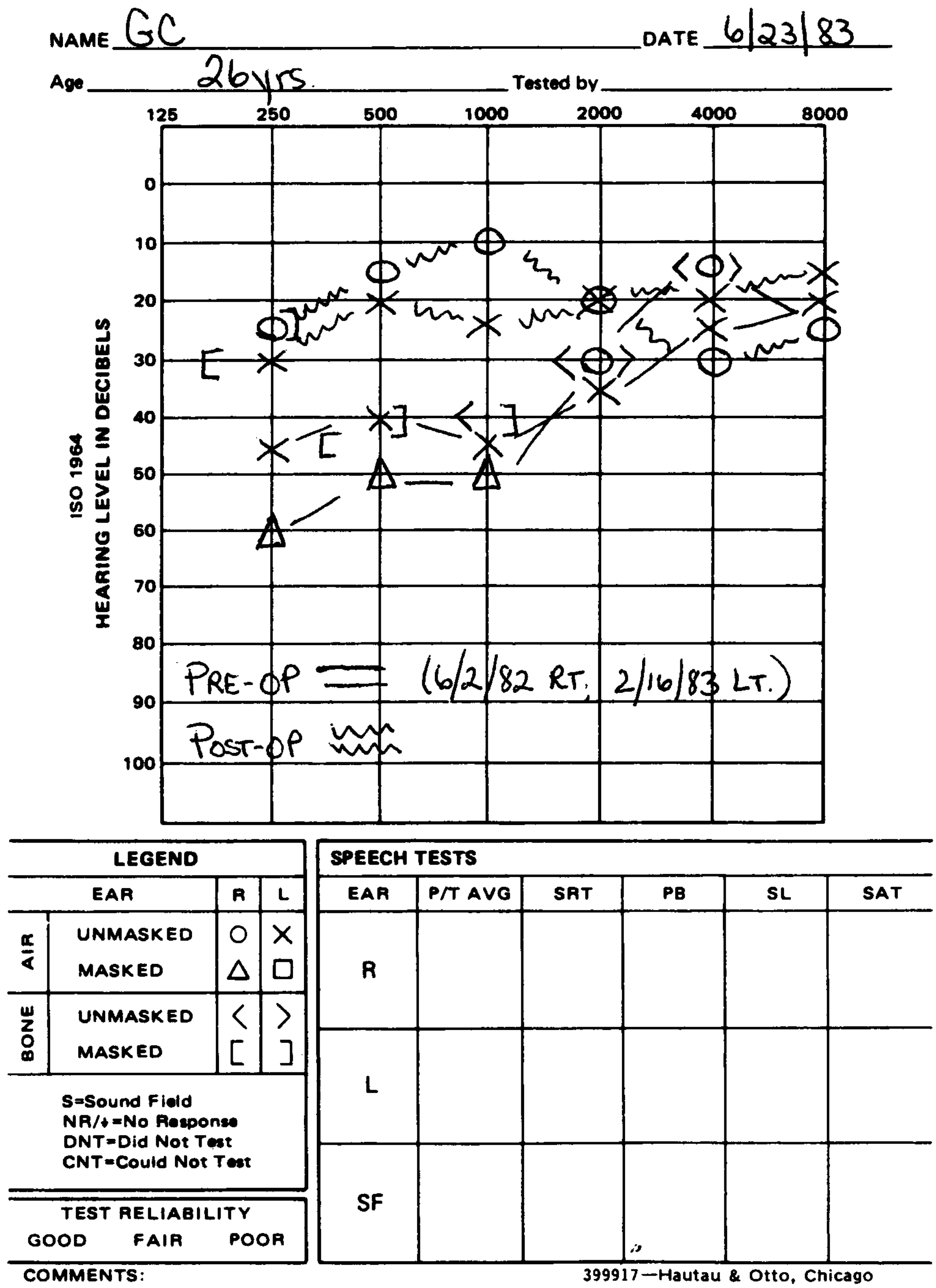

Figure 1. Audiogram indicating a minimal conduction deficit in a patient with otosclerosis.

alternately before either ear and compared with the presumably normal hearing of the tester.

The Weber test with the 256-Hz tuning fork placed on the bony nasal dorsum or forehead may be heard by the patient in one ear, or it may not lateralize. When lateralized to the impaired ear, it is a dependable indication of a conductive loss; and when lateralized to the better hearing ear, of a sensorineural loss.

The Rinne test is performed first with the 256-Hz tuning fork activated by striking against the palm and held alternately in front of the meatus and with its stem pressed against the mastoid process. The result is recorded as "negative" when heard longer by bone, "positive" when heard longer by air, or "equal" when heard approximately the same by air and by bone. A negative Rinne test result for the 256-Hz fork calls for this same test with the 512-Hz and 1,024-Hz forks to quantify the size of the conductive defect.

The Schwabach test compares the hearing by bone conduction with that of a normal tester by

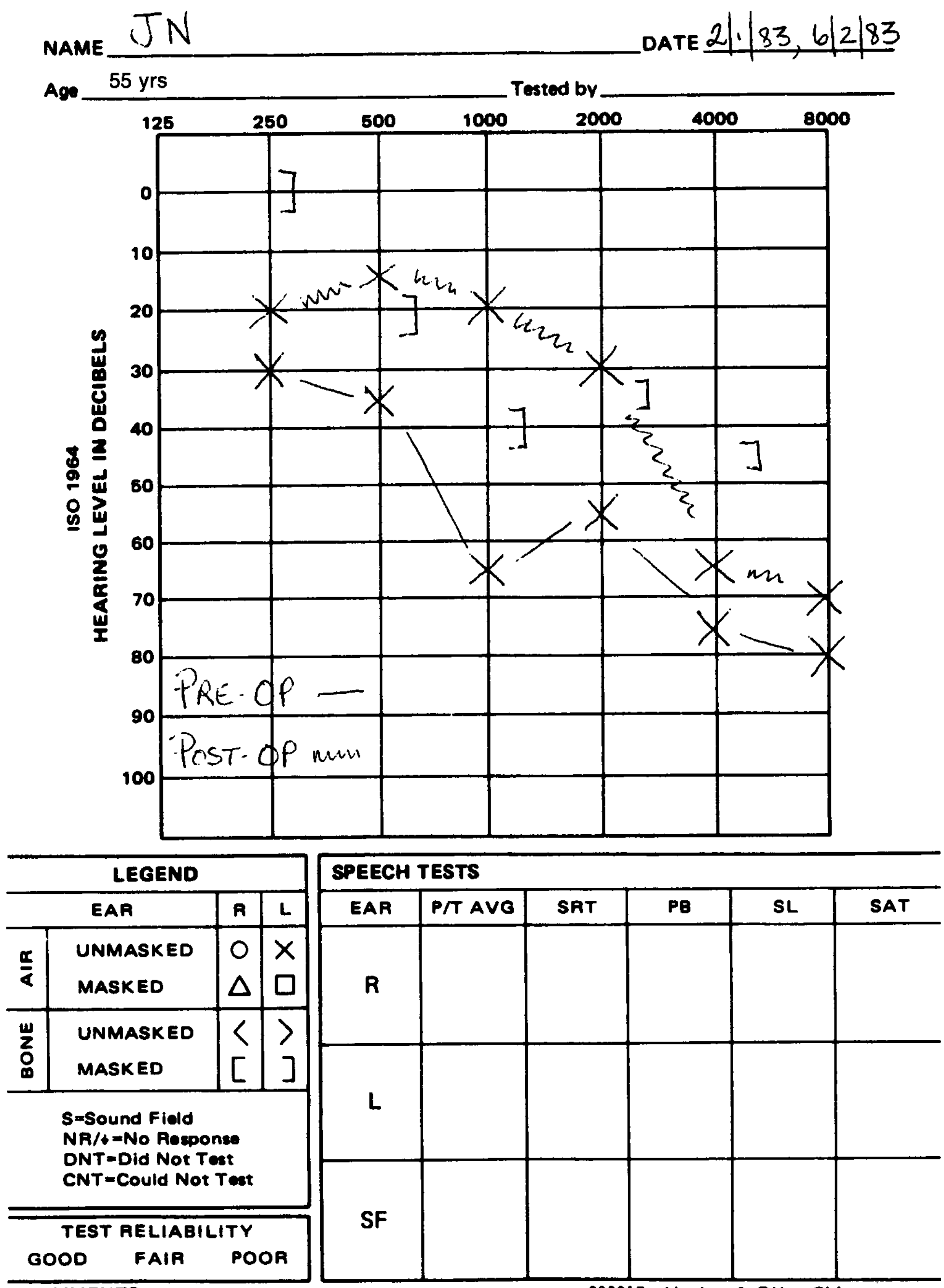

Figure 2. Audiogram of a patient with a previous stapedectomy with hearing loss who had revision stapedectomy with a Robinson prosthesis.

placing the stem of the 256-Hz tuning fork alternately on the patient's mastoid and the tester's mastoid. It is estimated as normal, shortened (slight, much, or not heard), or prolonged. The Schwabach test with the 2,048-Hz fork is useful in establishing the prognosis for perfect or less than perfect hearing after stapedectomy, since when the bone conduction is impaired, a residual high-tone sensorineural loss will occur after stapedectomy.

Without masking of the normal "good" ear, the air conduction audiogram will show a loss of 40 to 60 dB in a completely "dead" nonfunctioning ear, by sound heard around the skull from the normal side.

TUNING FORK TEST VIS-A-VIS AIR AND BONE AUDIOMETRY FOR SURGICAL INDICATIONS

Case One

A 26-year-old woman had a history of progressive hearing impairment suggesting otosclero-

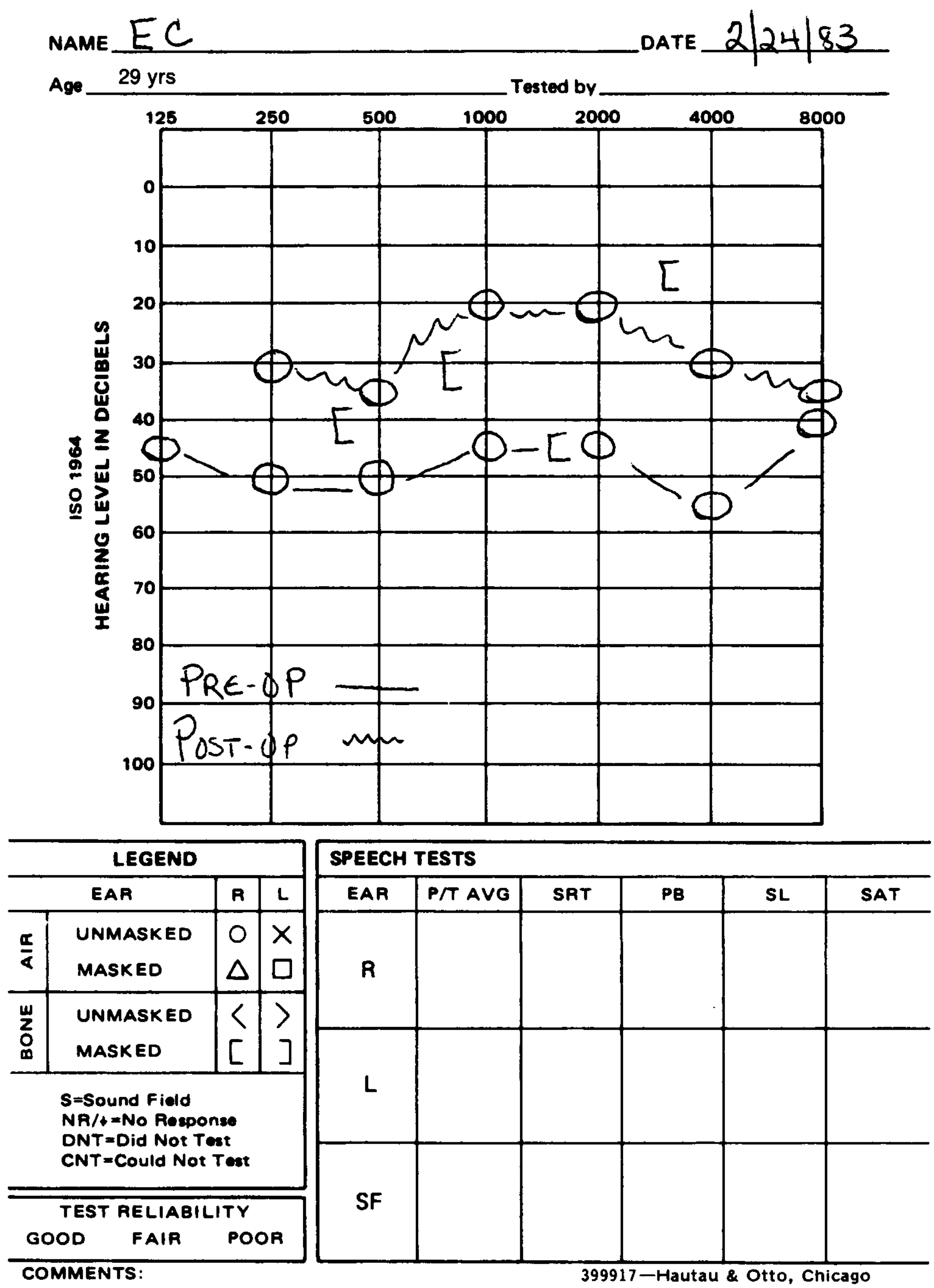

Figure 3. Audiogram after stapedectomy in a patient in whom audiometry originally showed a minimal air–bone gap.

sis. Acoustic reflexes suggested ossicular fixation, but the air and bone audiogram (Fig. 1) indicated only a minimal conduction deficit. Polytomography failed to show pathology of the cochlear capsules, oval windows, or ossicles. However, the Rinne test was negative with the 256-Hz and 512-Hz tuning forks. On the basis of these findings, stapedectomy was done for the right ear and improved the hearing for the speech frequencies from 43 to 15 dB. The audiometric bone curve improved from the 38-dB to the 20-dB level after surgery, indicating a rather large preoperative "Carhart notch"[5] associated with otosclerotic stapes fixation. Eight months later, a stapedectomy was performed on the left ear with similar results. Without the tuning fork tests this patient with her small audiometric air–bone gap would not have been considered suitable for stapedectomy.

Case Two

A 55-year-old woman had a stapedectomy in 1966 with wire prosthesis against compressed Gel-

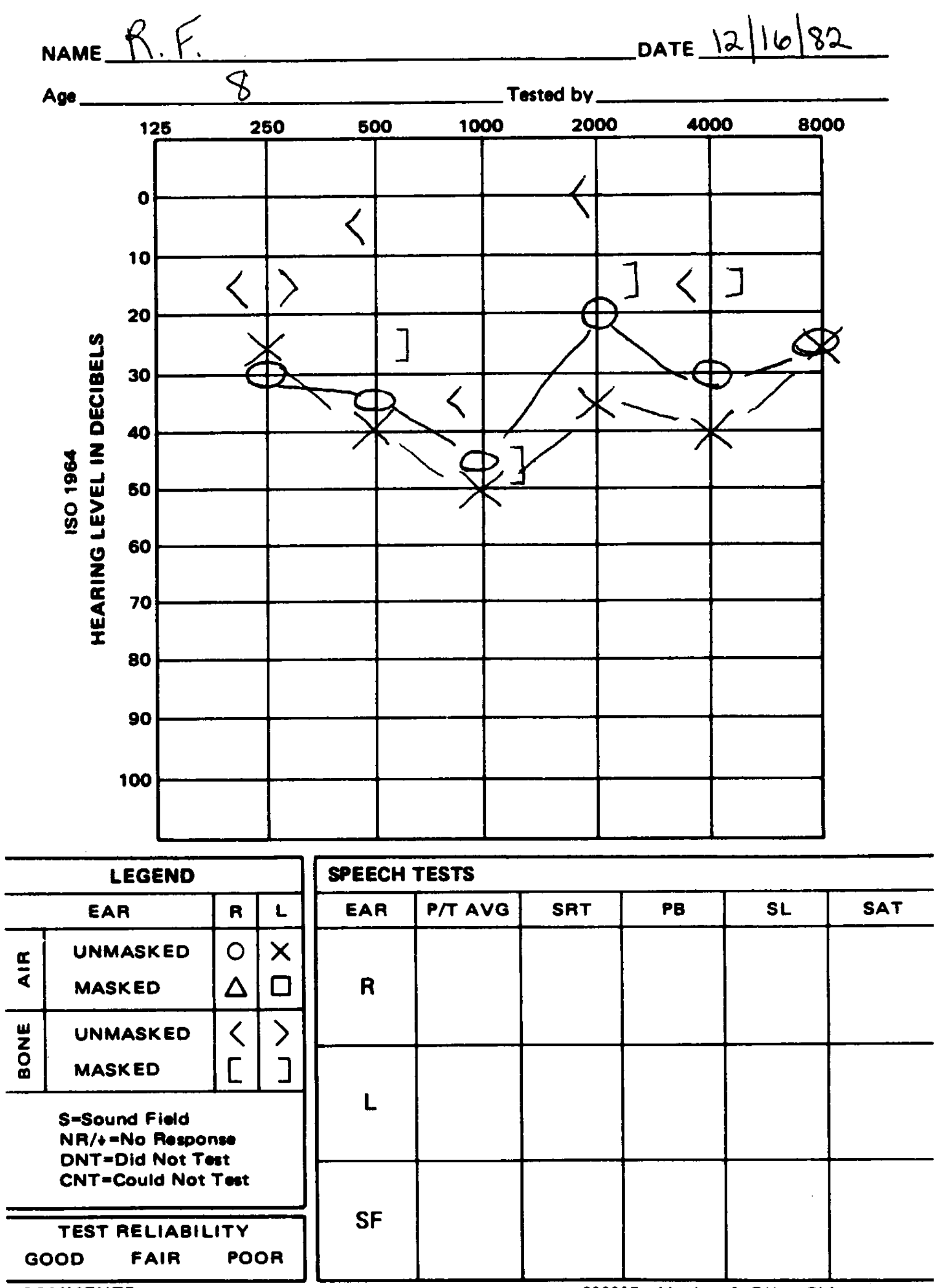

Figure 4. Audiogram of a patient with an air–bone gap on audiometry but a 256-Hz positive Rinne test.

foam with initial closure of the air–bone gap. The hearing in this ear gradually declined to a 52-dB level for the speech frequencies in February 1983, and the bone conduction declined to 32 dB. The Rinne test was negative at 256 Hz but equal at 512 Hz, encouraging a revision despite the poor audiometric bone conduction. Revision with a Robinson prosthesis improved hearing to the 22-dB level for the speech frequencies (Fig. 2).

Case Three

A 29-year-old man presented with a minimal air–bone gap by audiometry not sufficient to advise surgery. However, a negative Rinne test for 256-Hz and an equal Rinne test for 512-Hz encouraged stapedectomy. The result (Fig. 3) was hearing improvement to the 25-dB level for the speech frequencies.

Case Four

An 8-year-old girl was referred for surgery for an audiometric air–bone gap. However, the 256-Hz Rinne test was positive. Surgery should never be advised to improve hearing when there is a positive Rinne test for the 256-Hz tuning fork despite an audiometric air–bone gap (Fig. 4).

Case Five

A 53-year-old woman complained of a loss of hearing and persistent vertigo following stapes surgery on the right ear. This patient experienced a slowly progressive hearing loss in both ears of 4 years' duration, for which she had seen an ear specialist who told her that she had a nerve loss and that there was no effective treatment for this. Her hearing loss continued to worsen slowly. She consulted a second ear specialist and this one, on the basis of a small air–bone gap on the audiogram, decided that there was a possibility of help through stapes surgery. A stapedectomy on her right ear was performed on February 15, 1977, but without any improvement in hearing. A reoperation for a possible displaced prosthesis was done in April of the same year, and this, too, failed to improve her hearing; in fact, it resulted in a severe hearing loss with persistent dizziness. Hearing tests revealed a pure sensorineural hearing loss in her unoperated ear, with excellent discrimination consistent with cochlear otosclerosis. The right ear showed a profound sensorineural loss with poor discrimination. A destructive labyrinthectomy was advised and carried out because of the persistent dizziness. Sodium fluoride was used to stabilize the hearing in the left ear.

The patient has been observed for 3 years following the labyrinthectomy on the right ear, and the hearing in the left ear has remained stable, presumably the result of the sodium fluoride. Because of the unsuccessful operation on the right ear the patient has sued the physician for operating for a wrong diagnosis. If tuning fork tests were used prior to surgery, this mistake could have been avoided.

In addition to these five examples in which tuning fork tests were helpful in deciding for or against surgery, a false conductive hearing loss may occur audiometrically by meatal collapse from pressure of the earphone. This not infrequent error is quickly detected by a tuning fork check. Another source of audiometric error may be a vibrotactile response to the bone oscillator, suggesting nonexistent bone conduction hearing in a patient with a "dead" ear or a shadow curve with insufficient masking of the better ear.

SUMMARY

Results of tuning fork tests are consistent with those of audiometric tests in most cases and merely confirm them. In all cases, of course, adequate masking of the better ear is needed for audiometric bone testing and tuning fork tests when the hearing level between the ears varies by 40 dB or more.

We regard tuning fork tests as a valuable adjunct to air and bone audiometry. They should be a part of the diagnostic workup of every patient with impaired hearing, especially if surgery is being considered.

REFERENCES

1. Stankiewicz JA, Nowry HJ: Clinical accuracy of tuning fork tests. Laryngoscope 1979;12:1956–1963.
2. Sheehy J, Gardner G, Hambley W: Tuning fork tests in modern otology. Arch Otolaryngol 1971;94:132.
3. Rinne A: Contributions to the physiology of the human ear. Prager Vierteljahrschr Praktische Heilkunde 1855;1:71–113.
4. Schwabach D: On the value of Rinne's experiment for the diagnosis of the diseases of the hearing apparatus. Z Ohrenheilkunde 1885;14:61–148.
5. Carhart R: The clinical application of bone conduction audiometry. Arch Otolaryngol 1950;51:498.