**Fitting Strategies for Patients with Unilateral Hearing Loss**

**MICHAEL VALENTE, MAUREEN VALENTE, JANE ENRIETTO, KAREN M. LAYTON**

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**Introduction**

Patients with unilateral hearing loss typically have difficulty with (1) locating the sources of sound, (2) understanding speech when the signal arrives on the side of the poorer ear, and (3) understanding speech in background noise (especially if the noise is arriving on the side of the better ear). Patients with unilateral hearing loss can present a challenge to the dispensing audiologist. The dispenser can choose a traditional dispensing model, which suggests providing extensive counseling on the communication problems likely to occur as a result of unilateral hearing loss, or recommend contralateral routing of the signal (CROS) amplification to the good ear. On the other hand, the dispenser could explore with the patient several alternate fitting strategies.

This chapter focuses on the problems associated with unilateral hearing loss and provides information beneficial for dispensers who want to explore alternative fitting strategies for patients with unilateral hearing loss.

**Definition of Unilateral Hearing Loss**

For the purposes of this chapter, unilateral hearing loss is defined as unaidable hearing in one ear and normal hearing [15 dB hearing level (HL) or better at 250 to 8000 Hz] in the opposite ear. Unaidable hearing is defined as an ear having one or more of the following characteristics:

1. Profound sensorineural hearing loss so that amplified sound cannot be heard with any degree of usefulness.
2. Very poor word recognition score.
3. Marked intolerance for amplified sounds.

**Incidence and Prevalence of Unilateral Hearing Loss**

Although information is available regarding the incidence of unilateral hearing loss in children (Bess and Tharpe, 1986; Kielmovitch and Friedman, 1988; Oyler et al, 1988; Brookhouser et al, 1991), there is less information regarding the incidence of unilateral hearing...
loss in adults. Much of the information regarding the incidence of unilateral hearing loss in adults involves sudden hearing loss, often as a result of illness (Van Dishoeck and Bichman, 1957; Petheram, 1976; Shannon et al, 1982), otologic surgery (acoustic neuroma), or nonotologic surgery (Arenberg et al, 1972; Wright and Saunders, 1975; Plasse et al, 1980; Millen et al, 1982).

Rambur (1989) reported that the incidence of sudden unilateral hearing loss in the United States was approximately 40,000 per year, equally distributed between males and females. Her report and reports by By (1978) and Berg and Pallach (1981) indicate that sudden hearing loss usually occurs in adolescents or older adults, with the greatest incidence occurring between 30 and 60 years of age (Megighian, 1986). Hearing loss was usually unilateral, although Rambur (1989) and Megighian (1986) found bilateral sudden hearing loss in up to 17% of the cases.

Bergenius (1985) studied vestibular findings in sensorineural hearing loss. Of 1,635 patients undergoing audiologic evaluation from 1979 to 1982, 12.9% fulfilled the criteria for “pure unilateral sensorineural hearing loss or tinnitus alone.” Noury and Katsarkas (1989) cited various references that stated that sudden hearing loss has no sexual predilection and a mean age of occurrence between 40 and 47 years of age. Sudden hearing loss is usually unilateral, although Rambur (1989) and Megighian (1986) found bilateral sudden hearing loss in up to 17% of the cases.

Bess and Tharpe (1986) and Tharpe and Bess (1991) estimated that nearly seven million Americans have some degree of unilateral hearing loss. They quoted a prevalence rate for school-aged children of 3:1000 in which hearing loss was 45 dB HL or greater, which increased to 13:1000 if milder losses (26 to 45 dB HL) were included. They provided no information for children under age 3 years. The authors reported that Everberg (1960) revealed a greater prevalence of unilateral deafness among males (62.3%) than females (37.7%); he also reported a higher rate of left ear impairment (52.5%). Of interest is that unilateral impairment is generally detected later in life because speech and language skills appear to develop more normally. Of Everberg’s 122 subjects, 52.5% were identified after the first year in school. Bess and Tharpe (1986) cited Tarkkanen and Aho (1966) to corroborate these findings, with an average identification age of 6 years. The hearing loss in 50% of the children was not detected until 7 years of age or older, which the authors find unacceptable in view of the deleterious effects unilateral hearing loss has on academic performance (see below) (Bess and Tharpe, 1986).

Brookhouser et al (1991) investigated unilateral hearing loss in children, the results of which may lend information related to adult populations. They also reported an incidence in unilateral hearing loss of 3:1000 when including hearing loss greater than 45 dB HL or 13:1000 when including hearing loss between 26 and 45 dB HL. They reported that Kinney (1953) found 1307 cases of sensorineural hearing loss in children, of which 48% were unilateral. Of 1829 consecutive patients studied by Brookhouser et al, 690 (37.7%) had asymmetrical hearing loss. Of those 690 cases, 391 (56.7%) were described as having isolated unilateral sensorineural hearing loss. When 67 of these 391 cases were deleted from the study (due to various factors, such as conductive component), the authors reported on the results of 324 children; 62% were males and 38% were females. The left ear was affected in 52% and the right ear was affected in 48%. This find-
ing was not statistically significant. The investigators felt their statistics were consistent with previous investigators’ preponderance of males over females. However, previous findings of greater right-sided versus left-sided hearing losses were not supported by this study.

Tieri et al (1988) observed 280 cases of unilateral sensorineural hearing loss from 1979 to 1986. The age range was 8 months to 12 years, with a mean age at diagnosis of 7.6 years; 62% were males and 38% females. They felt these findings were in agreement with those of Tarkkanen and Aho (1966) and Hallmo et al (1986). The right ear was affected in 49.6% of cases and the left ear in 50.3% cases. Degree of hearing loss ranged from mild to profound, with 79.3% falling in the latter range. In addition, 250 audiograms revealed a flat configuration. Tieri et al, noting that incidence is difficult to evaluate, cited the following statistics: Everberg (1960), an incidence rate of 0.06%; Tarkkanen and Aho (1966), 0.09%; and Kinney (1953), 8.5%. Tieri et al noted that 24.7% of their children were diagnosed before the age of 6 years, as compared with the 47.5% under 7 years noted by Everberg and the 7% before school age noted by Hallmo et al. They concluded that school age diagnosis may be a result of critical teacher observation, older children’s awareness of sensory skills, and exposure to a greater number of infectious diseases.

Although no clear-cut statistic is available regarding the incidence of unilateral sensorineural hearing loss in adults, perhaps the findings summarized earlier in this chapter may provide some insight. The incidence of unilateral hearing loss is of such significance that audiologists and otologists should be prepared to see these patients on a regular basis and plan rehabilitation programs to help maximize the residual hearing in both the affected and better ear.

**Etiologies**

Unilateral hearing loss can be present at birth (congenital) or at any time after birth (acquired). Congenital unilateral hearing loss can be genetic (dominant, recessive, or sex-linked) or nongenetic [cytomegalovirus (CMV), low birth weight, syphilis, mumps, or anoxia]. In addition, unilateral hearing loss can be acquired at any age, and the resulting hearing loss may be progressive, fluctuating, or sudden.

Several investigators have examined the etiology of unilateral hearing loss in children. In each investigation, the cause of the unilateral hearing loss was unknown (idiopathic) in the majority of cases. Kinney (1953) reported that of known causes in a series of 310 children, meningitis, measles, mumps, and mumps were the most common etiologies. Tieri et al (1988) examined 280 children between 1979 and 1986 and found that the etiologic factor was known in only 23% of the cases, and that of the known factors mumps was predominant. Everberg (1960) evaluated 122 children with unilateral hearing loss and noted that congenital factors are responsible for approximately 75% of the cases, with heredity being the major causal factor.

With the recent technologic advances in the treatment of neonates, additional risk factors for unilateral hearing loss have emerged. These include persistent pulmonary hypertension of the newborn (PPHN) (Hendricks-Munoz and Walton, 1988), hyperbilirubinemia (Bergman et al, 1985), intraventricular hemorrhage (Slack et al, 1986), and low birth weight (Clark and Conry (1979). Although these factors are most typically associated with bilateral hearing loss, unilateral hearing loss has also been reported.

Other less common causal agents have also been reported and include chicken pox (Hendricks-Munoz and Walton, 1988), CMV (Pass et al, 1980), Meniere’s disease (Hendricks-Munoz and Walton, 1988), trauma (Hendricks-Munoz and Walton, 1988), and perilymphatic fistula (Goodhill et al, 1973). Middle ear disease, such as congenital cholesteatoma and otitis media, has been known to cause unilateral hearing loss.
Many external ear deformities such as congenital atresia of the external auditory canal are typically unilateral.

Many of the causes of childhood unilateral hearing loss can also cause adult-onset or acquired unilateral hearing loss. Mumps and other viral etiologies (Wilson et al, 1983) such as viral labyrinthitis are well-known causes of unilateral hearing loss in adults. Other well-documented etiologies include vascular pathologies (occlusion, emboli, hemorrhage) (Arenberg et al, 1972; Wright and Saunders, 1975), neoplasms (acoustic neuroma), and labyrinth membrane ruptures (perilymphatic fistula) (Goodhill et al, 1973). Meniere’s disease has been reported to cause unilateral hearing loss in approximately 50% of all cases (Schuknecht, 1991). Head trauma, leading to a transverse (sensorineural hearing loss) or longitudinal (conductive hearing loss) fracture of the temporal bone can precipitate a unilateral hearing loss. In addition, syphilis, Cogan’s syndrome, postotologic surgical loss, multiple sclerosis, perilymphatic fistula, herpes zoster oticus, hemorrhage, thrombosis, embolism, spasms, aneurysm, and sludging of blood have been reported to cause unilateral hearing loss (Jerger and Jerger, 1981). Table 9–1 summarizes many etiologies that have been reported to cause unilateral hearing loss in children and adults.

<table>
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<tr>
<th>Study</th>
<th>N</th>
<th>Pathology</th>
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<td>Kinney (1953)</td>
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Problems Associated with Unilateral Hearing Loss

The individual with unilateral hearing loss can no longer enjoy the advantages of binaural hearing. For the interested reader, the advantages of binaural listening are covered in greater detail in Chapters 7 and 8 and in Valente (1982). These advantages include:

1. elimination of the head shadow effect,
2. presence of the squelch effect,
3. improved localization, and
4. presence of binaural summation.

Head Shadow Effect

The head shadow effect for spondee words was initially described by Tillman et al (1963), who reported that, as a spondee word arrives from one side of the head (near ear or monaural direct), the intensity of the signal is attenuated across the head by an average overall level of 6.4 dB before the signal reaches the opposite ear (far ear or monaural indirect). Furthermore, the head shadow effect increases as a function of frequency. For example, at frequencies above 2000 Hz, the intensity level of the signal to the far ear can be as much as 15 to 20 dB less intense than the level of the signal at the near ear (Markides, 1977; Hodgson, 1986).

The reduction in signal level in the higher frequencies at the far ear can have a significant impact on speech recognition. For example, if speech is delivered to the impaired ear side and noise directed to the good side (monaural indirect) at the same intensity level, the patient can experience great difficulties in communicating. In this situation, the speech signal is reduced overall by 6.4 dB to the good ear due to the head shadow effect, but the noise is unattenuated to the good ear. As a result, a −6.4 dB signal-to-noise ratio (SNR) is present at the good ear. Furthermore, a +6.4 dB SNR is present at the impaired ear (monaural direct) because the noise is attenuated by 6.4 dB but the signal is unattenuated. In essence, the unilaterally impaired patient has a 13-dB deficit relative to the same listening situation for a normal hearing patient. Clearly, if this listening situation is reversed, then the unilaterally impaired patient is not at a disadvantage relative to the normal listener.

Valente (1982) summarizes a series of studies concerning speech recognition for monaural direct versus monaural indirect listening. The advantage of monaural direct to monaural indirect word recognition can be as high as 20% to 50% depending on the type of signal, noise, azimuth, and SNR.

Squelch Effect

Giolas and Wark (1967), Koenig (1950), and others (Keys, 1947; Markides, 1977; Gulick et al, 1989) have described the advantages of binaural hearing to “squelch” or reduce the deleterious effects of background noise and/or reverberation on speech recognition. Gulick et al (1989) reported improved binaural “release from masking,” particularly when time, intensity, or phase differences of the signal are present (i.e., signal presented at any azimuth in a sound field other than 0 degrees, and these differences are not present for the masker (i.e., masker presented at 0-degree azimuth). That is, the presence of differences in time, intensity, and/or phase of the speech signal between the two ears will result in improved performance compared with the situation in which these differences are not present between the two ears.

Localization

Gulick et al (1989) devoted a section of their text to sound localization, describing various studies that have contributed to our knowledge. Explanations of directional hearing have centered on differences in stimulation between the two ears in time and intensity (i.e., duplex theory of localization) and the integration of this information for improved sound localization. In particular, the normal listener uses interaural time (low-frequency cue) and intensity differences (high-frequency cue) for improved localization in the horizontal plane. If there were a large difference in
hearing between the ears, localization skills would be reduced.

**Binaural Summation**

Brookhouser et al (1991) report that individuals with binaural hearing demonstrate improved thresholds for pure-tone and speech stimuli that are presented binaurally (Keys, 1947; Shaw et al, 1947; Pollack, 1948; Breaky and Davis, 1949; Reynolds, 1960). Gulick et al (1989) described this binaural summation phenomenon as an advantage in processing information (specifically, detecting threshold) with two ears over listening with one ear. They stated that if the ears are equally sensitive, the binaural threshold is about 3 dB better than the monaural threshold and the binaural advantage expands to 6 dB during suprathreshold listening (i.e., most comfortable loudness) and 10-dB sensation level (SL). This additional advantage may have significant effects on improved word recognition scores when listening binaurally in comparison to monaural listening. That is, if speech recognition increases at a rate of 5% per each additional decibel (i.e., articulation function), then the binaural advantage at suprathreshold levels could be 30% better (6 dB × 5% dB) than the monaural score.

**Performance in the Classroom**

Several studies have described the deleterious effects of unilateral hearing loss on children. Bess and Tharpe (1988) studied a group of 60 children with unilateral sensorineural hearing loss (greater than 45 dB HL in the speech frequencies). They felt that children would experience similar listening difficulties as adults, especially in the classroom and with language development. In their study, they found that 35% failed at least one grade (rate for general school population was 3.5%), and an additional 13.3% required resource assistance at school. A greater incidence of behavior problems was reported also. There seemed to be a correlation between early onset/severity of loss and risk for experiencing academic difficulties. Oyler et al (1988) reported a failure rate of 2% for grades kindergarten through eight, which is approximately 10 times greater than in the normal-hearing population. Some children were even reported to have dropped out of school. Brookhouser et al (1991) reiterated that children with unilateral loss may be disadvantaged in the classroom, particularly if noise occurs close to the better ear. These children do not have the advantages of normal-hearing children in selecting meaningful signals mixed with background noise. Localizing a sound source in horizontal plane may also present difficulty. Brookhouser et al appear to corroborate reports of academic and behavioral difficulties. Suggestions for teachers and parents were listed, including careful audiologic/otologic monitoring and strategies to alleviate localization and auditory figure-ground difficulties.

Bess and Tharpe (1986) provide a profile of the unilaterally hearing-impaired child who experiences academic difficulty:

1. Severe to profound sensorineural hearing loss
2. Early age of onset
3. Impairment in the right ear.

Culbertson and Gilbert (1986) reported decreased performance in word recognition, language, and spelling. The investigators provided some useful suggestions for management strategies, especially within the classroom.

Bovo et al (1988) submitted a questionnaire to 115 unilaterally hearing-impaired individuals who had become impaired during the first 12 years of life; 55 males and 60 females were included in their study, with 62 having hearing loss in the left ear and 53 in the right ear. Seventy percent were over 6 years of age when diagnosed. Difficulties in speech recognition and localization were described, as well as feelings of embarrassment, passivity, and avoidance. Twenty-two percent failed at least one grade, 12% received special services in the area of learning disability, and 27% described embarrassment and a sense of inferiority. Fifty percent
had not been provided preferential seating. The investigators recommended counseling classroom teachers in the areas of reducing environmental noise levels and reverberation in the classroom.

**Patient's Perspective of Unilateral Hearing Loss**

Giolas and Wark (1967) stated that, although communication difficulties for patients with unilateral hearing loss have been minimized by some professionals in the past, the difficulties can be quite significant. A report by Harford and Barry (1965) described some of the significant difficulties encountered by these patients. The investigators interviewed 20 patients with unilateral hearing loss. An increased difficulty in recognizing speech in noise (i.e., reduction or elimination of the binaural squelch effect) was reported as the most adverse listening situation. The greatest difficulty appeared when the noise was directed to the better ear and speech was directed to the impaired ear (i.e., head shadow effect). However, speech recognition was reported to be “affected” regardless of location of the speech or noise to the “good” ear. Interviewees further reported difficulty with localization of the sound source, especially in noisy situations. In addition, there was difficulty receiving and understanding speech, even in quiet, when the sound source was some distance away. They expressed feelings of confusion, embarrassment, helplessness, and annoyance. On a final note, interviewees were interested in responding to the questions, because they felt professionals had not expressed concern regarding their communication difficulties.

From another patient’s perspective, Bardon (1986) described some of the detrimental physiologic effects accompanying unilateral hearing loss. Both dizziness and tinnitus, which can accompany unilateral hearing loss, are frightening and bothersome; in addition, if a hearing loss is sudden, it can be especially confusing and distressing. Bardon felt that the extensive test batteries that patients undergo to diagnose etiology are time-consuming and may be somewhat stressful. He acknowledged that some reports describe unilaterally impaired children as having only minor communicative difficulties, if any. Adults were felt to have even fewer difficulties, especially if the loss developed later in life; these viewpoints were opposed by Bardon.

Bardon went on to state that tinnitus was a “masker” that interfered with speech perception. Furthermore, it was harder to attend to tasks, and he found himself shifting his head to perform tasks better. Large rooms such as hallways, hotel lobbies, and airports created difficult listening environments where sounds appeared blended. Several talkers at the same time presented difficulty, as did competing conversation or music during dining conversation. There were difficulties outdoors, and in some situations (such as in traffic) there was a safety issue involved with reduced localization abilities. Additional listening difficulties were encountered when the sound came from behind, when visual cues were limited, and with children’s voices. The quality of listening to music was affected with monaural listening, as was the ability to monitor the patient’s own speaking voice. Feelings of fatigue and irritability seemed to accompany continual attempts to perceive conversations and other meaningful stimuli. Professionals were urged to take note of these deleterious effects in counseling their patients and helping them to recognize the need to change their listening situations and lifestyles.

**Hearing Aid Fitting Process for Unilateral Hearing Loss**

**Case History and Referral**

As mentioned earlier, the problems associated with unilateral hearing loss appear to have been largely ignored by hearing health care professionals. In addition, patients with unilateral hearing loss generally perform well in quiet or have the ability to rotate their head so that the good ear is directed toward the speech signal and therefore may
not consider amplification to be required or beneficial. However, rotation of the head so that the good ear is directed toward the speech signal is not always possible. For example, if a patient has an anacusic right ear and is driving a car with a passenger on the right side, it would be very difficult, if not impossible, for the patient to rotate his head so his good left ear is facing the passenger!

When attempting to provide audiologic care for patients with unilateral hearing loss, the audiologist should seek answers to some important questions prior to considering amplification. Information should include the age of the patient, occupation, demands on listening, and indications of motivation toward amplification. Many authors (Harford and Dodds, 1966; Harford, 1969; Matkin and Thomas, 1972; Hodgson, 1986; Courtois et al, 1988; Pollack, 1988; Kenworthy et al, 1990) have stated that there is a greater likelihood of success with amplification in this group if (1) a high degree of motivation is present toward amplification, (2) the demands on listening are high because of lifestyle or occupation, and (3) the patient is an adult. These authors report a higher rate of failure with CROS amplification when attempted to be fitted for children. Kenworthy et al (1990) reported significantly greater success during monaural direct listening with an FM auditory trainer coupled to the better ear than with either CROS amplification or recommending preferential seating in children with unilateral hearing loss.

The patient history should include as much detail as possible regarding the duration and etiology of the hearing loss and any related symptoms such as tinnitus or dizziness. Like any other hearing aid fitting, the audiologist should require a medical clearance prior to dispensing hearing aids. This is especially true in cases of unilateral hearing loss, because the hearing loss may be the result of a space-occupying lesion.

If the hearing loss is sudden, waiting several weeks before pursuing amplification is suggested because approximately 65% of cases of sudden hearing loss report complete or partial recovery (Rambur, 1989). Management of sudden unilateral hearing loss may include vasodilating drugs, anticoagulants, histamine, cervical ganglion blocks, steroids, inhalation therapy of 95% oxygen and 5% carbon dioxide, and calcium antagonists (Rambur, 1989).

Fitting Options

CROS

One of the most successful attempts in helping patients with unilateral hearing loss overcome the head shadow effect was the introduction of CROS in 1964 (Harford and Musket, 1964; Harford and Barry, 1965; Harford and Dodds, 1966; Harford, 1969; Punch, 1988). In the earliest version, CROS amplification consisted of a microphone placed over or near the unaidable ear to pick up signals arriving at the side of the impaired ear. The output from the microphone was wired to an amplifier, receiver, and volume control, via a headband, and the amplified signal was delivered via tubing gently placed in the open ear canal of the good ear. Due to the presence of the open earmold, no gain was provided below 800 Hz and only marginal gain was provided between 800 and 1500 Hz. The greatest amount of gain was provided in the frequency region above 1500 Hz. Therefore, patients likely to receive the greatest benefit from CROS amplification were patients with normal hearing in the good ear through 1500 Hz and a slight to mild hearing loss above 1500 Hz.

An eyeglass version of the CROS aid soon became available, with the wire running through the frames of eyeglasses. For those who did not wear glasses, the CROS was developed into behind-the-ear (BTE) hearing aids connected by a wire worn under the hairline. One of the major drawbacks of CROS amplification was the need for a wire to connect the output from the microphone on the impaired ear to the receiver on the good ear. To solve this problem, Telex introduced a wireless BTE to BTE CROS (Fig. 9–1), BTE to in-the-ear (ITE) bilateral CROS (BICROS) (Fig. 9–2), and BTE to BTE Multi-CROS (Fig. 9–3) hearing aids in 1973. The
CHAPTER 9  ■  FITTING STRATEGIES FOR UNILATERAL HEARING LOSS  261

wireless CROS uses an amplitude modulated carrier frequency to transmit signals from the microphone on the side of the impaired ear to the receiver placed in the good ear. The distance between the transmitter and receiver is critical (approximately 6.5 inches). For every half-inch increase in distance between the transmitter and receiver, there is a 3- to 4-dB decrease in gain (Punch, 1988). Currently, three CROS models and BICROS models are available from Telex. In each of these cases, the receiver portion is placed in the near normal ear (CROS fitting) or better ear (BICROS) and all the models include adaptive compression.

Clinically, one of the major drawbacks of the wireless CROS/BICROS systems is the limited ability to shape the frequency-gain response to provide the prescribed gain to the aided ear. Most of the wireless hearing aids are delivered with only a low-frequency tone control or a low- and high-frequency tone control as a means to shape the frequency response. Due to this limitation, the authors over the past several years have

Figure 9–1. Example of a wireless behind-the-ear (BTE) to BTE contralateral routing of signal (CROS) hearing aid. Note the absence of a volume control on the hearing aid on the right. The hearing aid on the right is the transmitter side (placed over the poorer ear) and the hearing aid on the left is the receiver side (placed over the good ear). (From Telex Communications, Inc., with permission.)

Figure 9–2. Example of a wireless BTE to in-the-ear (ITE) bilateral CROS (BICROS) hearing aid. Note the absence of a volume control on the hearing aid on the left. The hearing aid on the left is the transmitter side (placed over the poorer ear) and the hearing aid on the right is the receiver side (placed in the good ear). (From Telex Communications, Inc., with permission.)

Figure 9–3. Example of a wireless BTE to BTE MultiCROS hearing aid. Note the presence of volume controls on both sides. The hearing aid on the right is the receiver side (placed over the better ear; C, CROS; BC, BICROS; T, telephone) and the hearing aid on the left is the transmitter side (placed over the poorer ear; M, microphone on; O, microphone off). (From Telex Communications, Inc., with permission.)
been proactive in counseling patients on the advantage of being fit with *wired* programmable CROS/BICROS hearing aids (Fig. 9–4) that have several advantages over the *wireless* systems. First, this aid is programmable, which allows the audiologist greater flexibility in shaping the frequency-gain response of the hearing aid to either match a prescribed target or to present an aided signal that the patient feels has better sound quality. Second, and more importantly, this aid contains a dual-microphone that provides the user with greater intelligibility of speech in noise than the omnidirectional microphone (Valente et al, 1995) available on the wireless models. Using a counseling session favoring the advantages of dual-microphone technology in more effectively addressing the issue of improved intelligibility of speech in noise, our clinic has had such success with these *wired* CROS/BICROS hearing aids that we have not dispensed any *wireless* CROS hearing aids over the past 5 years.

Clinically, the authors have experienced some confusion within the professional community with the nomenclature used for CROS/BICROS fittings. When the aided signal is being routed to the left ear, it is important to remember that this is a *left CROS or BICROS fitting*, whereas on the other hand, a *right CROS or BICROS fitting* means that the aided signal is routed to the right ear.

Although CROS amplification effectively eliminates the head shadow effect by amplifying signals from the hearing-impaired side, localization and speech intelligibility in noise still remain a problem. Some CROS users report some improved localization based on differences of the quality of sounds from the two ears. If the signal appears “natural,” it may be judged to be arriving from the good side. If the sound appears “tinny” or “metallic,” it may be judged to be arriving from the impaired side (Harford, 1969). Also, if the level of ambient noise is high, few users of CROS amplification report any significant benefit regardless of which side the signal or noise may be arising from. In these environments, it is best to counsel the patient to reduce the volume control setting or remove the hearing aids (Hodgson, 1986; Harford, 1969; Pollack, 1988; Punch, 1988).

One final point must be emphasized regarding CROS amplification. In the original report by Harford and Barry (1965) and subsequent reports by Harford (1969), Harford and Dodds (1966), Courtois et al (1988), and

Figure 9–4. Example of a wired CROS hearing aid with remote control. The hearing aid on the left is an off-microphone placed over the poorer ear. The hearing aid (with dual microphones) on the right is placed over the better ear. The hearing aid on the right can be programmed so that when the switch is placed in the “M” position the aid provides omnidirectional performance and when placed in the “T” position the aid provides dual-microphone performance. When used with the remote control, the “T” position is used for telecoil and the patient can be provided omnidirectional performance by pressing “I” and dual-microphone performance by pressing “II” and/or “III” (depending on how the hearing aid is programmed by the audiologist). This remote control also allows the user to turn the hearing aid “on” and “off” and increase (“+”) or decrease (“−”) the volume.
Punch (1988), there is a clear recommendation that success with CROS amplification is significantly related to the magnitude of hearing loss in the good ear. If hearing in the good ear is within normal limits, then the probability of success with CROS amplification will be minimal. On the other hand, if a mild hearing loss is present above 1500 Hz, then a greater probability of patient acceptance will be achieved. Our experience with CROS amplification over the past several years supports this recommendation. Very few (less than 10%) of our patients with normal hearing in the good ear reported that the benefits from CROS outweighed their perceptions of the presence of “harshness” or “tinniness” of the amplified sound heard in the good ear. Based on these findings, we have adopted a policy that CROS amplification is not our primary choice for unilaterally hearing-impaired listeners if the patient has normal hearing in the good ear. On the other hand, CROS becomes our primary recommendation if a mild to moderate high-frequency sensorineural hearing loss is present in the good ear above 1500 Hz.

**TRANSCRANIAL CROS**

Another approach to providing benefits of amplification to the unilaterally hearing-impaired has been advocated by several authors (Sullivan, 1988; McSpaden and McSpaden, 1989; Miller, 1989; McSpaden, 1990; Charrand, 1991), who suggest placing a high-gain, high-output ITE or BTE hearing aid into the impaired ear to take advantage of the fact that the cochleas for each ear, which are contained within the temporal bone, are not acoustically isolated. That is, if a signal of increasing intensity is presented to the cochlea of an impaired ear, the signal will eventually be heard in the cochlea of the better ear because it will be intense enough to overcome the acoustic isolation [interaural attenuation (IA)] between the cochleas of the two ears. Because the signal picked up by a microphone placed in the impaired ear is transferred to the cochlea of the good ear through the cranial structures of the temporal bone, the authors referred to this type of fitting as a transcranial CROS.

The concept in developing the transcranial CROS is apparent to any audiologist who has experience in testing a patient via air conduction (earphone or insert receiver) who has normal hearing in one ear and a moderately severe to severe hearing loss in the opposite ear. That is, the initial unmasked air conduction threshold for the impaired ear represents the magnitude of interaural attenuation (i.e., “shadow curve”). For this patient, this represents the lowest intensity at which stimuli (nonspeech or speech) will pass through the temporal bone and be heard by the cochlea of the normal ear. In much the same way, the output (input signal plus the gain of the hearing aid) from a strong BTE or ITE hearing aid placed on the impaired ear can deliver sound to the cochlea of the normal ear via bone conduction. Signals picked up by the microphone of a hearing aid placed over or in the impaired ear can be amplified and eventually cross through the head and be heard by the cochlea of the normal ear via bone conduction (Miller, 1989).

In one study (Miller, 1989) comparing conventional CROS with transcranial CROS amplification, the subjects reported improved recognition of speech in “quiet” when the speech signal was presented to the impaired side, improved speech recognition in noise, and some improvement in the ability to localize. In addition, some subjects reported that the amplified sound presented through their transcranial CROS was more “natural” than the sound processed through their conventional CROS hearing aid. Other reports by McSpaden (1990), McSpaden and McSpaden (1989), and Sullivan (1988) indicated that listeners found transcranial CROS fittings were “more natural,” provided improved localization via cues from a metallic sound from the aided side and a natural sound from the normal side, and improved listening in noise when the signal was from the impaired-ear side. Patients did not report the harshness that some experience with CROS fittings.
In an effort to determine if transcranial fittings had merit, Valente et al (1995) evaluated 12 patients with an anacusic ear or profound sensorineural hearing loss in one ear and normal hearing in the opposite ear. For each patient, a strong ITE hearing aid (maximum saturation sound pressure level of 120 dB; full-on gain of 55 to 65 dB) with a long canal and pressure vent was fitted to the impaired ear. Four patients were experienced users of CROS amplification to the better ear. Two patients had experience with an eyeglass bone conduction hearing aid placed on the mastoid process of the impaired ear. Five patients had no experience with amplification, and one patient had experience with a mild ITE hearing aid coupled to the better ear. At the end of 4 weeks, half of the patients felt that the ITE transcranial CROS provided significant benefit, whereas the other half noted little additional benefit and decided to continue to utilize their current hearing aids or not pursue amplification.

It is important to remember that the acceptance rate at this facility for conventional CROS fittings for this population is 10%, whereas the acceptance rate for the transcranial CROS was 50%. It is interesting to note that the reasons for rejection of the transcranial CROS by many of the patients were related to feedback or to a sensation of vibration generated from the hearing aid. The results of this evaluation were encouraging, and we are currently in the process of directly comparing transcranial CROS BTE fittings (to eliminate, we hope, the problems related to feedback and at the same time provide greater output) to traditional CROS fittings in a large sample of unilaterally hearing-impaired adults.

CROS-plus

A modification of transcranial CROS was introduced by Hable et al (1990). This fitting system was coined “CROS-plus” by the authors because a traditional CROS is fitted to the better ear in the usual manner and is combined with a power ITE hearing aid placed in the unaidable ear. A recent modification of the eyeglass CROS version provides for the offside frame on the poorer ear to contain two microphones. One microphone is for the CROS or BiCROS arrangement to forward the signal to the better ear. The second microphone is part of a separate hearing instrument (i.e., microphone, amplifier, and receiver with a closed mold) to forward the signal to the poorer ear. This effectively eliminated the need for a separate ITE to be placed in the unaidable ear. In addition, this arrangement can be modified for BTE fittings to both ears. According to the authors, the CROS-plus has been fitted to over 150 patients for whom many report improved clarity of speech, improved localization, and improved recognition of speech in noise.

Bone Conduction

Whereas 30 to 50 dB or more of gain is necessary for the output from an air-conducted transcranial CROS fitting to reach the cochlea of the good ear, minimal gain is required for a signal delivered via bone conduction to reach the cochlea of the good ear. This is because interaural attenuation for a bone-conducted signal is virtually 0 dB. That is, as soon as a signal is transmitted by bone conduction to the cochlea embedded in the mastoid process of the temporal bone of one ear, it is instantaneously heard in the cochlea embedded in the temporal bone of the opposite ear. Therefore, the signal detected by the microphone placed over the anacusic ear and amplified by a bone conduction hearing aid is immediately heard in the cochlea of the good ear.

Fowler (1960) appears to be the first to have advocated placement of a bone-conduction hearing aid over the mastoid process of the impaired ear for patients with unilateral hearing loss. Usually, bone-conduction aids are advocated for ears with chronic middle ear drainage or an ear canal with atresia. Because interaural attenuation for a bone-conducted signal is negligible, only one ear is required to have normal hearing via bone conduction.
Bone-conduction aids are currently available in eyeglasses (Fidelity F228 or F229). In addition, bone-conduction aids are available in body aid or BTE configurations, with the bone vibrator tightly held in place on the mastoid process via a headband. Just like the transcranial CROS, a bone-conduction eyeglass hearing aid has a microphone, amplifier, volume control, and bone-conduction receiver mounted in the eyeglass temple behind the ear with a vibrating pad projecting slightly toward the mastoid process on the side of the impaired ear. It delivers sound from that ear, routing it transcranially via bone conduction to the cochlea of the normal ear. For a patient with an anacusic ear and normal hearing in the opposite ear, the bone-conduction aid can provide improved awareness and recognition of speech arriving on the side of the poor ear. However, like CROS and transcranial CROS amplification, bone conduction aids do not appear to improve localization significantly or the recognition of speech dramatically in high levels of background noise for most patients.

In an attempt to determine if fitting a bone-conduction hearing aid had any merit, the authors evaluated seven patients with anacusic hearing on one side following surgical removal of an acoustic neuroma. Of the seven patients, six decided to purchase the hearing instrument (rejection rate of 14.3%) after a 30- to 60-day trial period. Interestingly, one patient who decided to purchase the bone-conduction hearing aid had a long history of experience with CROS amplification. These seven patients reported similar improvements in communication that were described earlier for our patients using a transcranial CROS. Again, it is important to remember that the acceptance rate at this facility for conventional CROS fittings for this population is 10%, whereas the acceptance rate was 86% for an eyeglass bone-conduction hearing aid.

Although this fitting was very successful with this small group of patients, a bone-conduction eyeglass fitting is not without numerous obstacles. First, when the eyeglass is removed the patient will be without amplification. Second, not all unilaterally hearing-impaired patients have visual impairments and therefore may not be interested in pursuing an eyeglass fitting. This problem was solved for two patients by having the optician fit ordinary glass into the eyeglass frame. Third, it is very important for the bone vibrator to fit directly on the mastoid with sufficient static pressure to deliver the amplified signal effectively to the mastoid process.

Each eyeglass bone-conduction aid is available with a series of 10 extension tips to place the bone vibrator directly on the mastoid. It is often necessary to make several trips to an experienced optician before the ideal placement and pressure are achieved. For some patients, the required pressure necessary for maximum benefit from this type of hearing instrument may cause irritability of the skin under the bone vibrator, discomfort, and headaches. In fact, these problems led to rejection by one of our patients, although he found the hearing aid fitting to be beneficial. In addition, audiologists tend to stay away from eyeglass fittings because they themselves assume the patient would not be interested in pursuing such a fitting. The findings of Hable et al (1990), clearly point to the fact that the need to place hearing instruments in an eyeglass is not the obstacle many audiologists believe it to be.

**Verification Strategies**

**Sound-Field Evaluation**

Figures 9–5 illustrates a suggested procedure for evaluating sound-field unaided and aided speech recognition in noise for CROS, CROS-plus, and bone conduction hearing aids. Similar procedures have been suggested by Harford (1969), Skinner (1988), Pollack (1988), and Hodgson (1986). In Figure 9–5a, the signal [NU-6 word lists at 70-dB sound pressure level (SPL) on the C scale] is presented from a loudspeaker 90-degree azimuth on the side of the good ear, and multitalker babble is presented at 64 dB SPL (C scale) from a loudspeaker 90-degree
azimuth on the side of the unaidable ear. In this configuration, unaided and aided word recognition scores are determined with a calibrated +6 dB SNR without the head present.

It should be anticipated that the results using the loudspeaker arrangement illustrated in Figure 9–5a will reveal the best unaided and the poorest aided scores and thus the smallest difference between unaided and aided performance. That is, in the unaided condition the good ear is directly receiving the NU-6 words (70-dB SPL). The intensity level of the multitalker babble (64-dB SPL) presented from the side of the poor ear is reduced to the good ear by approximately 6.4 dB due to the head shadow effect (Tillman et al., 1963). This effectively reduces the noise level of the multitalker babble to 57.6 dB at the side of the good ear. Therefore, the effective SNR at the good ear has been improved to +12.4 dB (70–57.6 dB SPL), whereas without the presence of the head the SNR was calibrated at +6 dB (70–64 dB SPL). For the aided condition, the multitalker babble from the poor side is now amplified because a microphone is placed over or near the poor ear. In this situation, the reduction of noise to the good ear has been eliminated and the noise is amplified and mixed at fairly high levels with the unamplified signal entering the good ear directly.

In Figure 9–5b, the position of the subject remains the same, but the loudspeaker output has been reversed so that the signal arrives at the side of the unaidable ear, while the multitalker babble arrives at the side of the good ear. In the loudspeaker arrangement illustrated in Figure 9–5b, the audiologist should anticipate the poorest unaided and the best aided scores and thus the largest difference in aided versus unaided performance. In fact, it is not uncommon for the differences between unaided and aided performance to exceed 20 to 30%. In the unaided condition, the speech signal is on the side of the poor ear and is attenuated by approximately 6.4 dB to the good ear, whereas the noise is unattenuated to the good ear. In this situation, the effective SNR at the good ear is −12.4 dB for the same reasons described above, and unaided performance should be rather poor. In the aided condition, a microphone is on the side of the poor ear to deliver the amplified signal (either by air or bone conduction) to the good ear. This effectively eliminates the head shadow effect and significantly improves speech recognition scores in comparison to the unaided condition in which the head shadow effect was present.

Although the results of the four unaided and aided comparisons are fairly predictable,
it is important for the audiologist to complete these comparisons. These procedures clearly demonstrate to the listener the importance of placing the microphone on the impaired ear in a favorable position depending on the origin of the signal or noise to the impaired ear. In essence, this verification process allows the patient to experience the full spectrum of listening situations in which unaided and aided performance will be markedly different. That is, the listening situation in which the patient had the greatest difficulty without amplification (i.e., speech on the poor side and noise on the good side) will now result in the best listening environment with the use of amplification. On the other hand, the listening situation that created the least difficulty without amplification (i.e., speech on the good side and noise on the poor side) will now result in the poorest listening environment with the use of amplification. The patient needs to experience and realize that situations will arise in which amplification will provide a poorer listening environment in comparison to when amplification is not used.

Table 9–2 provides the speech recognition results for two patients using the loudspeaker arrangements discussed in the previous section. The results are for one patient fitted with a transcranial ITE CROS on the impaired ear and for a second patient fitted with an eyeglass bone-conduction aid with the bone vibrator placed on the mastoid process in the impaired ear. As can be seen for the transcranial CROS patient, the aided improvement was 2% for the condition described in Figure 9–5a where the NU-6 word lists were presented on the side of the good ear and the noise was presented on the side of the impaired ear. However, for the eyeglass bone-conduction patient, the aided improvement was 16%, which is significant at the 0.01 confidence level (Raffin and Thornton, 1980). When the listening situation was reversed as described in Figure 9–5b, the aided performance was 18% better than the unaided score for the ITE transcranial CROS and a 26% improvement for the eyeglass bone-conduction fitting, both of which were significant at the 0.01 confidence interval (Raffin and Thornton, 1980).

**Probe Measures for Traditional CROS Fittings**

The method of choice today for verification of hearing aid fittings is real-ear probe tube measures. For an in-depth description of real-ear probe tube measures, see Chapter 3 and Tecca (1990) or Valente (1991).

Probe tube measures can be a very useful tool for measuring the performance of CROS, transcranial CROS, and CROS-plus fittings. Punch (1988) suggested measuring the real-ear unaided gain (REUG) and the real-ear insertion gain (REIG) at 250 to 6000 Hz for a CROS fitting with the probe tube placed 6 cm from the mouth.

### Table 9–2. Speech Recognition Scores Measured in Sound Field (as Illustrated in Fig. 9–1)

<table>
<thead>
<tr>
<th>Aid</th>
<th>Unaided (%)</th>
<th>Aided (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transcranial CROS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NU-6 to good ear/multi-talker babble to the impaired ear (Figure 9–5a)</td>
<td>92</td>
<td>94</td>
</tr>
<tr>
<td>NU-6 to impaired ear/multi-talker babble to the good ear (Figure 9–5b)</td>
<td>74</td>
<td>92</td>
</tr>
<tr>
<td>Eyeglass bone conduction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NU-6 to good ear/multi-talker babble to the impaired ear (Figure 9–5a)</td>
<td>84</td>
<td>100</td>
</tr>
<tr>
<td>NU-6 to impaired ear/multi-talker babble to the good ear (Figure 9–5b)</td>
<td>56</td>
<td>82</td>
</tr>
</tbody>
</table>

CROS, contralateral routing of signal.
mm from the tympanic membrane of the good ear with the loudspeaker at 45- to 90-degree azimuth to the impaired ear where the microphone for the various CROS fittings will reside. He suggested that the measured REIG will demonstrate if the CROS fitting eliminated the head shadow effect because the measured REIG should not exceed the magnitude of the head shadow (6 to 7 dB) plus an amount of gain appropriate for the magnitude of hearing loss in the good ear between 1500 and 6000 Hz. Punch did not suggest a prescriptive procedure, but the National Acoustic Laboratories’ revised (NAL-R) prescriptive procedure (Byrne and Dillon, 1986) appears to be an appropriate choice for the magnitude of loss in the good ear, which is appropriate for a CROS fitting.

For fitting an ear with normal hearing in the good ear, less than 10-dB gain would be desired in the frequency region above 1500 Hz. For many CROS fittings measured at our facility, the measured REIG exceeds this goal, and this may be the major reason why many patients with normal hearing in the good ear reject CROS amplification.

Tecca (1990) indicates that several real-ear probe tube measures should be made for CROS fittings. First, Tecca suggests measuring the REUG, real-ear aided gain (REAG), and REIG with the loudspeaker at ±45-degree azimuth with the probe microphone in the better ear and the reference microphone placed over the poor ear. In this manner the audiologist first measures the REUG. Then the BTE or ITE CROS hearing aid is placed over or in the poorer ear, and the REAG is measured in the better ear. The REIG is calculated as the difference between the REAG and the REUG.

To determine the magnitude of the head shadow effect, the REUG can initially be measured with the loudspeaker at 45- to 90-degree azimuth to the good ear with the reference microphone over the good ear, but the probe microphone in the poor ear. The REUG is repeated with the loudspeaker relocated at 45- 90-degree azimuth to the side of the poor ear with the reference microphone moved to the poor ear, but the probe microphone remaining in the poor ear. The difference in the REUG between these two measures represents the magnitude of the head shadow effect, and it can be on the order of approximately 6 to 7 dB. In addition, these measurements illustrate the effectiveness of the microphone placed on the poor ear when desired signals originate from the side of the poor ear.

Finally, the REAG is measured once with the loudspeaker located 45 to 90 degrees on the side of the better ear. This REAG measure can be compared with either REUG mentioned in the previous paragraph. Comparison of the REAG to the REUG measured from the side of the poor ear determines the magnitude of the elimination of the head shadow effect. Comparison of the REAG to the REUG measured from the side of the good ear determines the “real” real-ear gain (REIG), and this should be compared with the prescribed REIG to verify if the patient is receiving adequate amplification.

 Probe Measures for Transcranial CROS Fittings

The authors developed a procedure using the real-ear aided response (REAR) that may be useful for the verification of transcranial CROS fittings. Using this procedure, the probe tube from the Frye 6500 real-ear analyzer is initially placed in the ear canal of the impaired ear at a distance of approximately 4 to 6 mm from the tympanic membrane, and the reference microphone is disabled. An earphone (or ER-3A insert receiver) is placed over the ear canal of the poor ear and unmasked air conduction thresholds are determined at 250 to 4000 Hz. Because these patients have known profound sensorineural hearing loss in the poor ear and hearing is within normal limits in the good ear, the unmasked thresholds represent the IA for the air-conducted signal. These thresholds can range between 40 and 90 dB HL depending on test frequency and intersubject variability. The SPL measurements from the probe microphone placed in the ear canal of the poor ear correspond to the individual IA.
at each test frequency. Next, the good ear is plugged and muffed while an ITE or BTE transcranial CROS hearing aid is placed in the poor ear. The volume control is adjusted to where amplification is comfortably loud while the patient listens to 70-dB SPL of speech-weighted composite noise presented by the loudspeaker from the Frye 6500. Finally, 70-dB SPL of speech-weighted composite noise is presented to the listener, and the REAR is measured to determine if it exceeds the IA previously measured in SPL in the ear canal of the aided ear. This process verifies if the amplified signal is sufficiently loud to be heard in the cochlea of the good ear via bone conduction.

Thus, when using this procedure, the “prescriptive target” for a transcranial CROS fitting is the measured SPL in the canal of the impaired ear corresponding to the IA. The goal is for the REAR to exceed that target by approximately 15 to 20 dB so that the amplified speech signal would be at a sensation level (re: IA threshold) sufficient to make the amplified signal audible in the cochlea of the good ear.

Table 9–3 provides an example of this procedure in a patient in whom a transcranial ITE hearing aid was fitted. In this case, the unmasked air conduction thresholds representing the interaural attenuation ranged from 55- to 75-dB HL (column 2, Table 9–3). With the probe microphone in the ear canal of the poor ear, the measured SPL in the ear canal ranged from 66.5-dB SPL at 1500 Hz to 89.3-dB SPL at 4000 Hz. With the transcranial ITE CROS placed in the poor ear, the REAR for 70-dB SPL of speech-weighted composite noise ranged from 63-dB SPL at 4000 Hz SPL to 96-dB SPL at 1000 Hz. More importantly, the aided REAR was below the measured earphone SPL response at 250 and 3000 to 4000 Hz (−6.6, −10.3, and −26.3 dB, respectively) and above the measured ear canal SPL response at 500 to 2000 Hz (+5.8, 16.5, 26.9, 19.5, and 2.7 dB, respectively). The goal for such a fitting would be that the aided REAR measures would provide approximately 15-dB sensation level or greater at 1000 to 4000 Hz. If this goal could be achieved without feedback or a sensation of vibration, then the audiologist could be assured that the amplified signal reached the cochlea of the good ear. Of course, these measures would be supplemented by the sound-field measures described above. It would be anticipated that the SPL of the REAR for this patient may have been greater if a BTE transcranial CROS had been fitted, because the appropriate volume control setting [i.e., adjusted to the most comfortable loudness (MCL) level] could not be achieved due to feedback.

In yet another approach for using real-ear probe tube measures to verify transcranial CROS fittings, Sullivan (1988) measured the occluded transcranial REIG in the good ear. To do this, he placed the probe tube near the tympanic membrane of the good ear, placed

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>IA Threshold (dB HL)</th>
<th>IA Threshold (dB SPL)</th>
<th>Measured REAR (dB SPL)</th>
<th>Sensation Level (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>60</td>
<td>80.6</td>
<td>74.0</td>
<td>−6.6</td>
</tr>
<tr>
<td>500</td>
<td>65</td>
<td>78.2</td>
<td>84.0</td>
<td>+5.8</td>
</tr>
<tr>
<td>750</td>
<td>60</td>
<td>69.5</td>
<td>86.0</td>
<td>+16.5</td>
</tr>
<tr>
<td>1000</td>
<td>60</td>
<td>69.1</td>
<td>96.0</td>
<td>+26.9</td>
</tr>
<tr>
<td>1500</td>
<td>55</td>
<td>66.5</td>
<td>86.0</td>
<td>+19.5</td>
</tr>
<tr>
<td>2000</td>
<td>60</td>
<td>77.3</td>
<td>80.0</td>
<td>+2.7</td>
</tr>
<tr>
<td>3000</td>
<td>70</td>
<td>87.3</td>
<td>77.0</td>
<td>−10.3</td>
</tr>
<tr>
<td>4000</td>
<td>75</td>
<td>89.3</td>
<td>63.0</td>
<td>−26.3</td>
</tr>
</tbody>
</table>

HL, hearing level; IA, interaural attenuation; REAR, real-ear aided response; SPL, sound pressure level.
a cotton block lateral to the end of the probe tip, and filled the ear canal with impression material. Warble tones were presented at 0-degree azimuth at 0.5 m using an input level of 60-dB SPL. Measurements were made in the occluded good ear with the transcranial CROS off (REUG) and at full-on (REAG) in the impaired ear. He reported a median occluded REIG of 9.5 dB at 1500 to 3000 Hz. One patient revealed an REIG peak gain in the occluded good ear of almost 25 dB in the 3000-Hz region.

**Conclusion**

Several fitting options are available for the sensorineural unilaterally hearing-impaired patient. The ideas contained in this chapter explored the concept that unilaterally hearing-impaired patients experience significant communication problems, and suggesting “turning your head to the desired signal” or recommending CROS amplification to the good ear should not be the exclusive rehabilitative options for these patients.

We have gained considerable experience with the fitting strategies outlined in this chapter and urge clinicians to consider transcranial CROS, CROS-plus, or bone-conduction amplification for unilateral hearing-impaired patients. We believe, and have demonstrated on numerous patients, that one or more of these “nontraditional” fittings may be more beneficial in many cases than “traditional” fittings.

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CHAPTER 9 ▪ FITTING STRATEGIES FOR UNILATERAL HEARING LOSS


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