

# FM Technology Use in Adults with Significant Hearing Loss

## Part I: Candidacy

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### Introduction

Numerous studies have documented the negative effects that noise has on the speech perception ability of listeners with hearing loss (Dubno, Dirks, & Morgan, 1984; Finitzo-Heiber & Tillman, 1978; Plomp, 1978; Ross & Giolas, 1971; Carhart & Tillman, 1970). Although conventional amplification can be of some benefit for listening in noise, for the most part conventional amplification is ineffective in improving the ability of listeners with hearing loss to understand speech in a noisy background. Basically, the problem is that for equivalent speech recognition in noise, the listeners with hearing loss require a more favorable signal-to-noise ratio (SNR) than do listeners with normal hearing. Thus the audiologic rehabilitation goal for these listeners with hearing loss is simply to improve the SNR of the listening environment. Currently the following two technologies improve the SNR and thus improve speech understanding: hearing aids with directional microphones and FM systems. Hearing aids with directional microphones improve the SNR by as much 8 dB (Ricketts & Dahr, 1999). In contrast to directional microphone systems, FM systems improve the SNR by as much as 15 dB, thus providing the most optimal strategy for improving speech recognition in noise (Hawkins & Van Tassel, 1982). The improved SNR provided by directional microphones benefits patients with moderately-severe to profound hearing losses, however, an even greater SNR will provide more benefit for these patients. While most research with FM systems has focused on pediatric populations, a few studies have examined FM performance with adults. These stud-

ies have documented the benefits provided by group assistive listening devices, including FM systems, in large area listening environments, such as auditoriums and classroom settings (Nabelek, Donahue, & Letowski; 1986; Nabelek & Donahue, 1986; Noe, Davidson, & Mishler, 1997).

Despite numerous demonstrations of improved understanding of speech in noise with the use of both systems, many individuals with adult onset hearing loss appear to prefer the use of hearing aids alone rather than hearing aids coupled with an FM system (Jerger, Chmiel, Florin, Pirozzolo, & Wilson, 1996; Lewis, Crandell, Valente, et al., 2002). In spite of the advantages of an FM system, there is a general lack acceptance of FM systems amongst potential adult users. Although reasons postulated for non-use include cost, complexity of device use, and increased attention to the hearing loss due to device visibility, it is also the case that we have no clear-cut criteria for determination of candidacy for FM use in adults, nor is there a systematic approach for device use training.

The goals of the present study were (1) identify candidacy criteria for potential adult FM users and (2) assess outcomes associated with benefit and cost for a group of subjects who received structured counseling on the use of the FM systems. Specifically this paper discusses the protocol and focuses on candidacy criteria. The companion paper in these proceedings (Chisolm, Noe, McArdle, et al. 2003) discusses results of the outcomes of benefit and cost.

### Methods

#### Participants

Forty-three veterans were enrolled for the study from the VA Medical Centers in Bay Pines, FL and

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Mountain Home, TN. To date, 31 subjects have completed the protocol and were included in the data analysis for these proceedings, 8 subjects have withdrawn, and 4 subjects are completing the protocol. Of the eight subjects who withdrew from the study: four were never fit with the FM system (two had no additional complaints once switched from ITE to BTE hearing aids with directional microphones and two rejected the use of BTE instruments), and three subjects were fit with FM systems but withdrew from the protocol because of health and family problems, and one subject did not like the FM system.

Inclusion criteria for the study included: (1) at least a moderate adult onset hearing loss with no evidence of retrocochlear pathology; (2) at least 6 months of hearing aid experience, (3) dissatisfaction with their current hearing aids in at least one listening environment in which an FM system would be beneficial, (4) appropriate reading and cognitive skills to participate in the study as determined through informal clinical assessment, and (5) no known neurological, psychiatric, or co-morbid diseases. Veterans with physiological or psychological problems that might preclude successful FM use were excluded from the study.

Figure 1 displays the average audiogram (circles) for the 31 subjects. No statistical differences were found between ears; therefore, only the thresholds for one ear are displayed. The squares denote the minimum loss and the triangles denote the maximum loss for the 31 subjects. Hearing aids used during the study included both analog and digital behind-the-ear

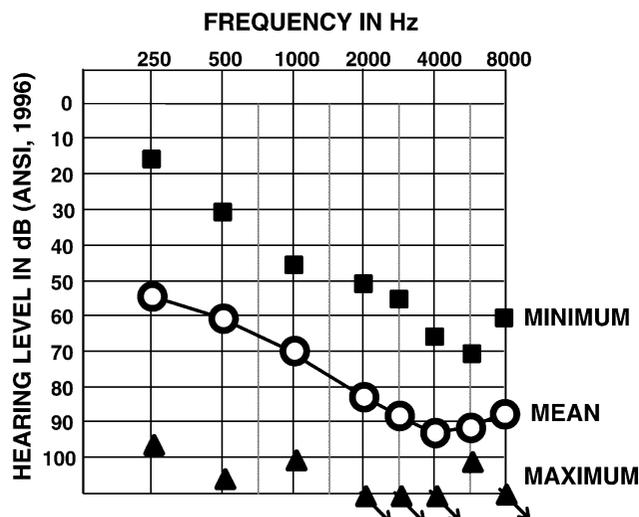


Figure 1

instruments. Table 1 provides a list of hearing aids used by the subjects enrolled in the study.

**Table 1.** Hearing aids used by subjects. The hearing aids were coupled to the MicroLink FM system.

Analog Hearing Aids	Digital Hearing Aids
Phonak Piconet 2P3	Phonak Claro 311
Phonak Sonoforte 2P2	Unitron Unison 2
Phonak PowerZoom	
Oticon Personic	
Oticon 380P	

## FM systems

All veterans were fit binaurally with the MicroLink FM system. The transmitters utilized in the study included the TX2 (body worn with lavalier microphone), TX3 (handheld unit) and the TX4 (Telcom). Based on communication needs expressed by the subjects, combinations of transmitters were used for some of the subjects. The MLx and ML8 receivers were used based on which hearing aid the subject was using. FM systems were verified using real ear insertion gain measures (Hawkins, 1984). The Frye 6500 real ear insertion measure instrument was used to verify the response of the FM system. During this procedure the hearing aid response was compared to the NAL-R insertion gain target (Byrne & Cotton, 1988). Because the subjects were experienced hearing aid users, some variations in the fitting target were seen due to patient preference. Next the FM transmitter was placed 15–20 cm from the speaker and the hearing aid and FM receivers were set to the 'FM only' mode. A 65 dB SPL composite signal was presented and the Real Ear Insertion Gain (REIG) was compared to the REIG of the hearing aid. According to Hawkins, the gain of the FM system will be greater due to a higher SPL caused by the differences in the distance from the speaker to the hearing aid (1 meter) and the distance from the speaker to the hearing aid (15–20 cm). The purpose of the verification was to assure the FM system was providing a smooth and appropriate frequency response when coupled to the hearing aid.

## Outcomes Measurements

Outcomes were measured with the following three standardized instruments: (1) *Communication Profile for the Hearing Impaired (CPHI; Demorest &*

Erdman, 1986); (2) *Markettrak* survey (Kochkin, 1990); and, (3) *Client Oriented Scale of Improvement (COSI)*; Dillon, 1997). The ultimate outcome measure was whether or not the subject decided to keep and use the FM systems after the trial period. In addition, to obtain an estimate of the perceived value of the FM system, each subject was asked how much he would be *willing-to-pay* for the FM device.

## Protocol

Veterans were seen in five individual sessions over seven weeks. In the first session adequate functioning of hearing aids was determined and any necessary adjustments to the hearing aids were made. Baseline outcome measures were obtained and individualized goals for FM use were determined. A minimum of one and a maximum of three goals were obtained for each participant. During the second session, which was one week later, the FM system was verified using the protocol previously outlined and the subject was instructed on use of the FM system. For each subject, individualized instructions were provided verbally, in writing, and with picture support describing how the FM system should be used to achieve the first goal. A diary was provided to the subjects and they were instructed to complete the diaries for each goal throughout the study protocol. The subject returned at two-week intervals for the third through the fifth sessions to discuss progress and receive instruction on using the FM system for the subsequent goals. If there were no new goals, then the previous goals were reinforced. During the final session outcome measures, willing-to-pay data, and a recorded interview were obtained. During this session the subject was given the choice of returning the device or keeping it for his personal use.

## Results and Discussion

The focus of this paper will be on using the results from outcomes data to define candidacy criteria for potential FM users. For information on FM benefit and willingness-to-pay data see the companion paper in these proceeding (Chisolm, Noe, McArdle, et al, 2004).

Candidacy selection was a 4-step process beginning with selecting possible participants based on the views of a group of clinicians experienced in fitting FM systems on adults. These clinicians developed the inclusion criteria previously outlined. Step 2 was an

examination of self perceived communication needs assessed using a shortened version of the CPHI (18 questions). These 18 questions assess how well a person perceives how well she/he can communicate in a variety of listening situations. Responses are on a 5-point Likert-scale ranging from “rarely or almost never” to “usually or almost always”. Step 3 examined user satisfaction with their hearing aids using the *Markettrak* survey instrument. *Markettrak* is a hearing aid satisfaction questionnaire that has been utilized by Knowles Electronics since 1989 (Kochkin, 1990). Responses from the subjects were compared to individuals with severe and profound hearing loss as reported in *Markettrak V* (Kochkin, 2000) and from the most recent survey all hearing aid wearers are reported in *Markettrak VI* (Kochkin, 2003). Step 4 used the COSI to determine the goals for FM use (Dillon et al, 1997). The COSI is an interview-style outcomes measure that requires the subject to nominate up to five listening situations in which help is needed with hearing.

## Communication Profile for the Hearing Impaired

The responses to the CPHI are summarized using the five scale scores shown on the abscissa in figure 2. Data from the 31 subjects from the FM study are

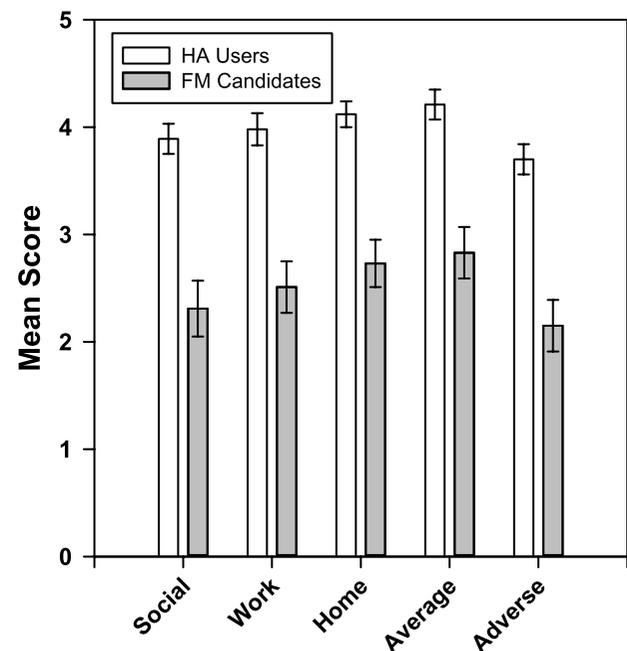


Figure 2

shown in the filled bars. For comparison, data from 105 veterans with mild-to-severe hearing losses enrolled in a Group Aural Rehabilitation study are shown in the shaded bars. Higher scores indicate better perceived communication. The data in the figure indicate that the FM candidates reported much poorer communication performance than did the larger comparison group of veterans. This finding was not unexpected since the group of veterans in the FM study had worse hearing. The data suggest that individuals who exhibit lower scores on self-report of communication performance might be candidates for FM devices. This may be further supported in that the patient who dropped from the study because he did not like the FM system scored closer to the veterans enrolled in the Aural Rehabilitation Study for adverse listening conditions than to the veterans enrolled in the current FM study.

## Marketrak

Subjects enrolled in the FM study completed selected questions from the Marketrak survey instrument. The use of the instrument provided the ability to compare data from the FM subjects to hearing aid satisfaction data from individuals with severe and profound hearing losses from Marketrak V (Kochkin, 2000) and from the most recent survey of all hearing aid wearers reported in Marketrak VI (Kochkin, 2003). The data in figure 3 show the percentage of participants in the FM trial (68%) who reported that they were 'satisfied' or 'very satisfied' with their hearing aids. These data were consistent with individuals with severe and profound hearing loss reporting overall satisfaction in Marketrak V. The results were also consistent with all hearing aid

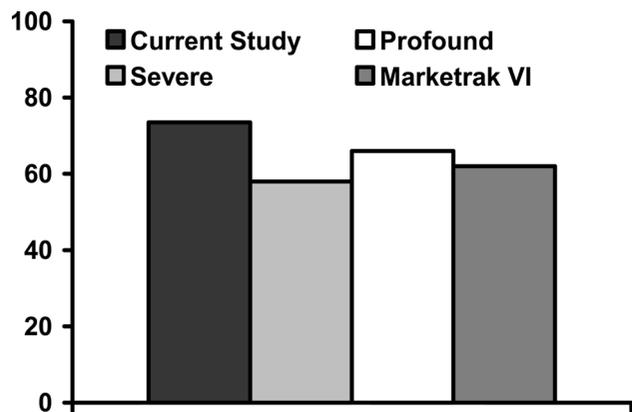


Figure 3

users in the most recent Marketrak VI. Overall satisfaction, therefore, is not a reliable criterion for FM candidacy. However, when subjects in the FM study were asked about satisfaction with hearing aid performance in certain listening situations, the responses differed considerably from subjects who responded to Marketrak VI. These specific listening situations included 12 items from the Marketrak instrument listed in table 2.

**Table 2.** Specific listening environments identified in the *Marketrak* instrument (Kochkin, 1990).

1. One-on-one
2. Television
3. Small groups
4. Listening to Music
5. Place of Worship
6. Outdoors
7. Leisure activities
8. Restaurant
9. Concerts/Movies
10. Workplace
11. Telephone
12. Large Group

When asked about hearing aid satisfaction in specific listening environments a substantially smaller percentage of individuals in the FM study were satisfied with hearing aid use compared to all hearing aid users surveyed in Marketrak VI. In addition, when asked if they were dissatisfied with hearing aid performance in these listening environments, a substantially larger group of FM subjects indicated dissatisfaction with hearing aid performance compared to Marketrak VI respondents. Chi square analyses were conducted to determine statically significant differences between the proportions of satisfied and dissatisfied individuals in each listening situation between the subjects enrolled in the FM study and the Marketrak VI database. Table 3 shows the seven different listening situations in which significant differences were found between the two groups. As can be seen by the listening environments listed in table 3, all of the situations are difficult listening environments resulting in poor SNR for the listeners due to presence of background noise, distance from the listener, or reverberation. Asking specific questions about hearing aid satisfaction, therefore, provides criterion for FM candidacy.

**Table 3.** Chi Square Analyses of listening situations from the Marketrak Instrument.

Listening Situation	Chi Square Analysis
In small groups	( $\chi^2 = 35.13, p < .0001$ )
In a place of worship	( $\chi^2 = 25.33, p < .0001$ )
Watching television	( $\chi^2 = 15.44, p = .001$ )
Listening to music	( $\chi^2 = 19.54, p < .0001$ )
In a restaurant	( $\chi^2 = 9.92, p = .003$ )
Riding in a car	( $\chi^2 = 16.06, p = .0001$ )
On the telephone	( $\chi^2 = 8.86, p = .003$ )

### Client Oriented Scale of Improvement

The COSI was used to identify listening situations that were difficult for the subjects even with the use of hearing aids. The subjects were asked to identify up to three goals for the study. Table 4 lists the goals identified by the subjects on the COSI. Communicating on the telephone was the most common goal, identified by 27 of the subjects. The majority of the goals identified by the subjects were listening environments in which the SNR is degraded by competing noise, reverberation, and distance from the speakers. This finding supports the results of the previously outlined data from the Marketrak studies in that FM subjects indicated dissatisfaction with hearing aid performance in similar situations as identified on the COSI.

**Table 4.** Goals identified by subjects on the *Client Oriented Scale of Improvement* [(COSI); Dillon, et al, 1997].

Listening Situation	Subject Goals			Totals
	#1	#2	#3	
1 or 2 in Quiet	4	3	2	9
1 or 2 in Noise	8	6	3	17
Group in Quiet	0	1	0	0
Group in Noise	5	7	5	17
TV/Radio	4	3	3	10
Telephone	6	4	15	25
Church/Meetings	8	6	2	16

### Conclusions

The data from this study indicate that the many adult listeners are candidates for FM technology.

Although FM systems are appropriate for any degree of hearing loss, this study focused on subjects with moderately-severe hearing losses. Standardized tools such as the CPHI, Marketrak, and COSI can aid in the identification of patients who may be candidates for FM technology. Based on these findings, FM candidacy criteria include:

1. Self-perceived communication difficulty with current hearing aids;
2. Dissatisfaction with hearing aids in specific listening environments that include reverberation, distance from the speaker, diminished visual cues, and competing noise; and
3. Specific listening situations encountered by the subject and identified as goal for improving communication with FM technology.

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