

DREAM CIC MICRO – SOUNDS GOOD, LOOKS EVEN BETTER

Introduction

The obvious attraction of completely-in-the-canal (CIC) style of hearing aid is its ease of insertion and cosmetic appeal, due in large part to its small size and canal placement. However, there are bountiful acoustic advantages as well. They include the ease of use over the telephone, reduced wind noise from its canal placement, increased high frequency input from the placement of the microphone in the concha, and sound localization. Kochkin (1995) reported that CIC wearers are much younger and more likely first time wearers of hearing aids. This style of hearing aid could potentially expand the hearing aid market by attracting younger hearing impaired wearers with a milder hearing loss (Kirkwood, 1996).

Although the main reason for CIC purchase is cosmetics, how this cosmetic advantage can be realized is dependent on several important factors:

- 1. Performance complexity of the DSP chip** - It does not do the hearing impaired wearer any good with an invisible CIC if it does not perform well. Performance is tied to the complexity of the signal processing algorithms available on the DSP hearing aid. The more complex the signal processing, the more transistors are needed within the DSP chip, leading to a potential increase in size. Indeed, it is a technical marvel that all the sophisticated processing within the DREAM hearing aid, such as True Input Technology, multi-channel compression, active feedback cancellation, noise reduction, frequency lowering etc, can be packaged into a CIC shell!
- 2. Output limitation of the CIC** – The acoustic output of a CIC hearing aid is affected by its receiver. Typically a larger receiver has a higher output; whereas a smaller receiver has a lower output. The fitting range of the CIC is ultimately tied to the receiver that is used in the CIC hearing aid. In order to fit a CIC to the widest range of hearing impaired listeners, one needs to choose the smallest receiver with the highest output and broadest bandwidth. The peak OSPL₉₀ of the DREAM CIC is measured at 115 dB SPL with a peak gain of 53 dB and bandwidth from 100 Hz to 9300Hz (as measured on a 2 cc coupler). These output characteristics allow the DREAM CIC to fit wearers with hearing losses even up to 90 dB HL. A smaller receiver would allow for a more cosmetic fit but it would limit the fitting range substantially.
- 3. Optional accessories on the CIC** – While the microphone, DSP chip, and receiver are critical components of any hearing aids including CIC, other space-occupying components may be considered optional on a space available basis. This includes the volume control, T-coil, larger battery door etc. It may be more difficult to decide if the wireless antennae (receivers and transmitter) used in today's wireless hearing aids are optional in a CIC. On the one hand, wireless enables all the inter-ear features (Kuk et al, 2011) which enhance the usability of the hearing aids and improve wearer satisfaction. On the other hand, the lack of wireless does not affect the fundamental operation of the hearing aid and it allows for a smaller CIC.

4. Size and shape of the individual ear-canal – The ear canals of hearing impaired individuals do come in different sizes and shapes. While the components listed previously can be assembled easily into a CIC hearing aid for an individual with an average, or a larger-than-average ear canal, they could present a problem for those with shorter, narrower, or more tortuous ear canals. In the later cases, one may have to sacrifice the performance and/or options to achieve an acceptable cosmetic fit with the CIC.

The current wireless DREAM CIC hearing aids are packed with state-of-the-art performance features (such as True Input Technology, Inter-Ear connectivity, advanced active feedback cancellation, speech enhancement and frequency transposition) that allow hearing impaired wearers with up to 90 dB hearing loss to enjoy the cosmetic (and acoustic) advantages of a CIC while experiencing the Widex sound quality. In order that more hearing impaired people with a “less than average” ear canal can enjoy the Widex sound quality in a discreet solution, Widex recently introduced the DREAM CIC-MICRO (CIC-M).

The DREAM CIC-MICRO is an evolutionary variant of the DREAM CIC. Our team of engineers and CAMISHA technicians studied various receiver types and their placements in the CAMISHA shell in order to determine the combination that requires the least space and provides the most stable gain. The conclusion is that new electronics without the wireless antenna is needed to replace the existing one with the antenna. This not only reduces the size of the DSP chip, but also eliminates the need to shield the receiver, further saving crucial space in a CIC hearing aid. Thus, a decision was made to make available a non-wireless version of the DREAM CIC, called the DREAM CIC-MICRO. This hearing aid has all the output characteristics and features as the DREAM CIC, except that it does not support any wireless functions. This includes wireless programming, inter-ear connectivity, and audio-streaming. As a result of removing the wireless features, the size of the DREAM CIC-MICRO is estimated to be up to 30% smaller than the DREAM CIC with the same receiver, with an even longer battery life.

The DREAM CIC-MICRO gives dispensers an extra option to their hearing impaired patients where discreetness is more important than wireless functionality. To document the improvement in cosmetic fit of the DREAM CIC-MICRO over the DREAM CIC, Widex conducted a multinational study where dispensers and end users were asked to view pictures of the two CIC variants in-situ, and judge the noticeability of the hearing aids.

Methods

This study required participants (hearing aid dispensers and hearing aid end users) to judge the visibility of the DREAM CIC and DREAM CIC-MICRO in-situ by studying pictures of model subjects wearing the devices.

Selection of the model ears

Twelve employees (6 females and 6 males) at Widex headquarters were selected randomly to serve as models. An ear impression was taken of the left ear and a DREAM CIC and a DREAM CIC-MICRO were made using CAMISHA technology. A picture showing the lateral view of the hearing aid in-situ was taken of all subjects from the exact location and lighting condition. These pictures were used as stimuli for subsequent evaluation. Other views of the hearing aids, such as the frontal view or of the hearing aids themselves were not used because the lateral view provided the most visible view of the hearing aids in situ. The following figure shows the comparison between the two CIC versions for one subject who showed the greatest contrast between the two CIC conditions (#2) and one who showed the least contrast (#12). The other model subjects showed intermediate differences in the appearance of the two CIC variants

Subject #2



Subject #12



Figure 1: Comparison between the DREAM CIC (left) and DREAM CIC-MICRO (right) for a subject who showed the most contrast (#2, top) and the least contrast (#12, bottom).

Participants

Dispensers and end-users within the Widex network in the USA, South America, Australia, and Europe were contacted via e-mail. They were asked to participate in the evaluation of the cosmetic fit of CIC models. The participants were informed that they would evaluate pictures of the physical fit of the two CIC models and to determine the noticeability of the hearing aids in the model subjects' ears through a self-driven, power-point presentation. The evaluation lasted about 20 minutes. The participants were blind to the type of CIC fitted (DREAM CIC or DREAM CIC-MICRO).

Thirty three dispensers participated in the trial. There were ten dispensers from Europe, 10 from South America, 6 from Australia and 7 from the USA. Twenty nine were female and 4 were male. They ranged in age from 25 years to 65 years with a mean age of 45 years. Twenty two of the dispensers worked in a private dispensing practice while 11 worked at a hospital or large clinic. They had an average of 19 years of experience, ranging from 1 to 40 years.

Thirty two end-users participated in the trial. Twenty two lived in Europe, 5 lived in South America, and 5 lived in Australia. Nineteen were male and 13 were female. They ranged in age from 25 to 76 years with a mean age of 52 years. Twenty seven subjects were actively working while 5 subjects were retired. Twenty one of the subjects were current hearing aid users.

Evaluation of the cosmetic fit

Participants (dispensers and end-users) were asked to judge the cosmetic fit of the two versions of CIC using two metrics – categorical judgment and paired comparison. Stimuli were pictures of the 12 model subjects' ears, each wearing the two versions of the DREAM CIC hearing aid (CIC and CIC-M).

Categorical Judgments

Categorical judgment task allows absolute judgment of performance, i.e., how noticeable was the hearing aid in situ. During this task, the 24 pictures of the 12 subjects were presented in a random order to the participants. They were asked to rate how noticeable the CIC was in the ear, using a five point scale - very noticeable, noticeable, neutral, unnoticeable and very unnoticeable. A "neutral" judgment would mean an expected appearance typical of a CIC hearing aid (i.e., acceptable). To avoid any biases, all the participants were blind to the hearing aid conditions (CIC or CIC-M).

Paired Comparison

Paired comparison task allows comparison of relative performance, i.e., is CIC-M better than CIC? During this task, the participants were presented two pictures of the same model subject's ear. One picture had the current DREAM CIC and the other the new DREAM CIC-M. The order of presentation of the CIC and the CIC-M was randomized. The participants were asked to select the CIC that was more discreet.

Results

A preliminary analysis of the responses showed that the responses of the dispensers were similar to those of the end-users on both the categorical ratings and paired comparison. A one-way ANOVA showed that the two groups of participants were not different in their responses ($p > 0.05$). Thus, their data were collapsed and reported together. Figure 2 shows a scatter-plot comparing the respondents' ratings on the DREAM CIC (X-axis) and the DREAM CIC-MICRO (Y-axis). The dotted diagonal line represents equal rating for both CIC versions. Data above the diagonal line represent higher (better) rating for the DREAM CIC-MICRO. Data below the diagonal line represent the opposite (poorer rating for the DREAM CIC-MICRO). The size of the "bubble" reflects the percentage of responses (out of a possible 774 data points) showing the unique combination of ratings on the DREAM CIC and DREAM CIC-MICRO. For example, the largest bubble in Figure 2 shows an entry of 19.8%. This suggests that 19.8% of the respondents (or 153) rated the DREAM CIC as "noticeable" but the DREAM CIC-MICRO as "neutral."

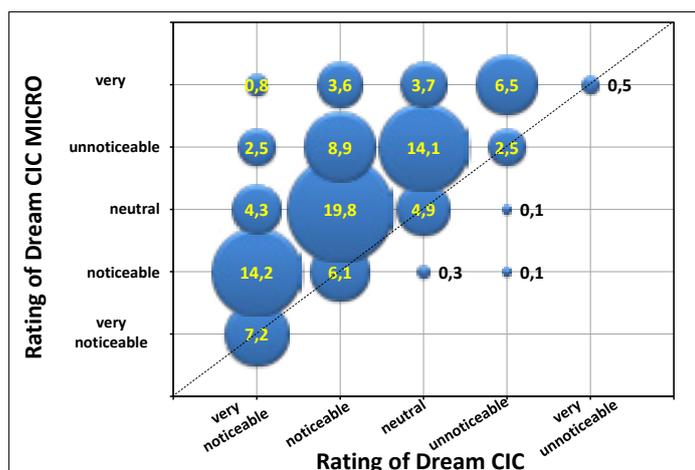


Figure 2: Scatter-plot comparing the ratings between the DREAM CIC-MICRO (Y-axis) and the DREAM CIC (X-axis) for all the participants (N=774). Numbers in each "bubble" represent the percentage of responses showing the unique combination of ratings.

There are several important observations:

1. Almost all the data points were at or above the diagonal; this suggests that the majority of DREAM CIC MICRO were rated higher than the DREAM CIC.
 - a. 0.5% (or 4) of the ratings were lower for the DREAM CIC MICRO than the DREAM CIC
 - b. 21.2% (or 164) of the ratings were identical between the DREAM CIC and DREAM CIC MICRO
 - c. 78.3% of the ratings (or 606) were higher for the DREAM CIC MICRO than the DREAM CIC
2. Over half (54.6% or 423) showed an improvement in rating of one interval. For example, from “very noticeable to “noticeable” or from “noticeable” to “neutral.” However, 16.9% (or 131) of the responses showed improvements of two intervals. For example, from “very noticeable” to “neutral” or from “noticeable” to “unnoticeable.” Fifty-three responses (or 6.9%) showed an improvement of three intervals, from “very noticeable” to “unnoticeable.”
3. 67.4% (522) of the ratings on DREAM CIC fell into the categories of “noticeable” and “very noticeable.” Still 32.6% (or 252) of the responses were either “neutral”, “unnoticeable” or “very unnoticeable.” While this confirms the need to have a cosmetic variant of the DREAM CIC, it suggests that the cosmetic fit of the DREAM CIC is acceptable in one third of the fittings. The distribution is shown in Figure 3.

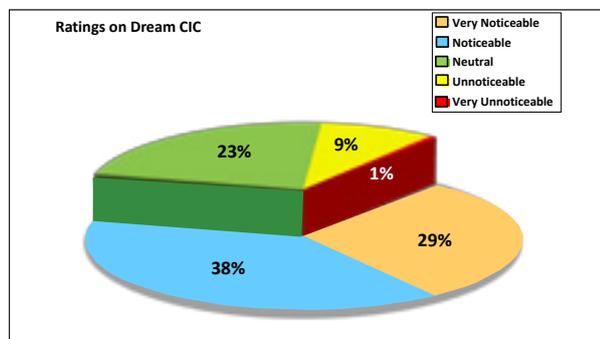


Figure 3: Pie chart showing the proportion of cosmetic fit of the DREAM CIC. The “pop-up” segment represents those with a better than “neutral” rating.

4. 72.2% (558) of the ratings on DREAM CIC MICRO fell into the categories of “neutral”, “unnoticeable” or “very unnoticeable.” Only 27.8% (216) of the ratings were “noticeable” and “very noticeable.” This is shown in Figure 4. This confirms that the majority of dispensers and end-users find the DREAM CIC MICRO to be cosmetically acceptable. A factorial repeated measures ANOVA revealed a statistically significant difference between the cosmetic fit of the DREAM CIC and DREAM CIC MICRO ($p < 0.001$).

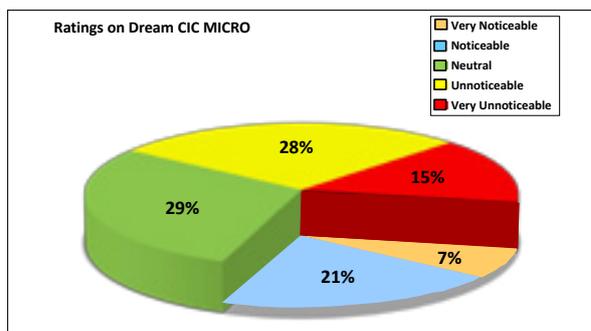


Figure 4: Pie chart showing the proportion of cosmetic fit of the DREAM CIC MICRO. The “pop-up” segment represents those with a better than “neutral” rating.

5. Not surprisingly, the results of the paired comparison showed that almost 100% of the comparison was in favor of the cosmetic fit provided by the DREAM CIC MICRO (Figure 5).

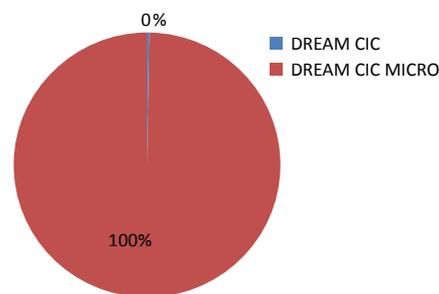


Figure 5: Percentage of responses that selected DREAM CIC-MICRO over the DREAM CIC during paired comparison.

Discussion

Results of the current study showed that the DREAM CIC-MICRO is noticeably smaller and more discreet than the DREAM CIC. This is confirmed by the results of the paired comparison where almost 100% of the data points were in favor of the CIC-M. Such a dramatic difference has also led to an improved rating of their noticeability – as much as 72.2% of the participants rated the CIC-M as “neutral”, “unnoticeable” or “very unnoticeable.” These data support the motivation behind the CIC-M as a cosmetic alternative of the CIC solution.

Individuals who place a high premium on the discreetness of the hearing aid, notably first time wearers with a mild hearing loss, those whose ear canals may not accommodate all the necessary and optional components in a CIC, will have now the DREAM CIC-MICRO as an appropriate solution. The DREAM CIC-MICRO wearer will enjoy all the sound quality advantages of the DREAM hearing aid and the cosmetic and acoustic benefits of a CIC style hearing aid. The only sacrifice is the enhancement and conveniences realized by wireless communication.

Those customers who place greater importance on the wireless functionality may choose the standard CIC solution. They will enjoy all the sound quality advantages of the DREAM hearing aid, the cosmetic and acoustic benefits of a CIC style device, and all the enhancement and conveniences realized by wireless communication. The only limitation may be a more noticeable hearing aid in-situ. However, it must be noted that not all DREAM CIC wearers would report the aid as “noticeable” or “very noticeable.” About 32.6% of the DREAM CIC responses were in the “neutral”, “unnoticeable” and “very unnoticeable” categories. It should be noted that individuals with a relatively large ear canal could possibly realize all the advantages of Widex sound processing and wireless connectivity while enjoying the full cosmetic and acoustic benefits of a CIC style hearing aid.

Because the physical fit of a CIC is even more dependent on the goodness of the ear impression, it is recommended that the dispenser first takes an accurate impression of the wearer’s ear. Based on the size and shape of the wearer’s ears, the dispenser can decide on the best CIC option to recommend (DREAM CIC or DREAM CIC-MICRO). In cases where both cosmetics and performance cannot be achieved, the wearer should be counseled the differences between the two CIC options in order to help guide their decision and set the appropriate expectations. A well informed patient is a satisfied patient.

References

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