# BC-1 as a replacement for the B71 bone vibrator

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**This paper shows that the BC-1, a bone vibrator from Natus, can be used as a direct replacement for the B71 bone vibrator, as the Reference Equivalent Threshold Force Levels (RETFLs) are applicable with the BC-1.**

## Purpose

The purpose of the study was to evaluate whether the BC-1 bone vibrator can serve as a direct replacement for the B71.

## Study

The performance tests of BC-1 against B71 were done for the typical measuring frequencies 0.25, 0.5, 0.75, 1, 1.5, 2, 3 and 4 kHz.

30 subjects participated in the study. All participants were tested using video otoscopy and tympanometry and found normal with regard to ear symptoms or defects. The group consisted of 23 males and 7 females – all recruited among staff. The mean age was 39 years, with the youngest 28 years and the oldest 60 years. All subjects were tested using air conduction and bone conduction.

The tests took place in an audiometric sound booth using the Bekesy test procedure. Test subjects used a patient responder connected to the audiometers.

The air conduction test was performed using insert earphones.

The bone conduction test was carried out twice – once for B71 and once for BC-1. Contralateral masking with narrow band noise at 30 dB EML sensation levels was applied through insert earphones.

Acoustic radiation from the bone vibrator was eliminated by occluding the test ear with an ear plug at test frequencies above 2 kHz.

The bone vibrator was placed on the mastoid close to the pinna. The placement was optimized by placing the bone vibrator for the largest sensation level based on the response from the test subject. A 1 kHz 40 dB HL pure tone was used in this step. The second bone vibrator was placed on the exact same position as the first one.

## Data analysis

Only subjects with air conduction hearing thresholds < 13 dB HL corresponding to 10 dB mean HL ± 3 dB HL variance were included in the data processing. This resulted in 24 subjects. Out of the 24 subjects, some had very good hearing showing a ceiling effect at certain frequencies. With that in mind, the final number of measurements at each test frequency was 19 or more. *See Table 1.*

Analysis of variance (ANOVA) and post hoc tests were applied in order to evaluate significance differences between the data from the two bone vibrators.

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To be able to detect a bias between the two groups of data (B71 and BC-1), the thresholds were subtracted from each group for each test subject. The experimental uncertainties due to lack of repeated measurements on each subject for a single measurement is set to 3 dB for bone conduction and 2.5 dB for air conduction – up to 4 kHz following the ISO 389-3:1994(E).

This suggests that the uncertainty for bone conduction is 4.2 dB of the difference data and for air-bone gaps 3.9 dB.

# Results

### Are the hearing thresholds obtained with B71 and BC-1 the same?

The results below compare the difference in performance of the BC-1 by subtracting the thresholds from BC-1 from the thresholds of the B71. Therefore, a positive value indicates that the BC-1 has higher thresholds than B71.

Table 1 illustrates the sample statistics of the difference. From the top: median, mean, sample standard deviation, combined standard deviation including uncertainty estimates, standard error of the mean (SEM), 95% confidence intervals based on SEMs, p-values and N.

| Frequency (Hz) | 250 | 500 | 750 | 1000 | 1500 | 2000 | 3000 | 4000 |
|---|---|---|---|---|---|---|---|---|
| Mean (dB) | -0.55 | 0.52 | -1.05 | -0.4 | 0.93 | -0.45 | -1.86 | 4.22 |
| Sample SD (dB) | 4.43 | 4.18 | 3.79 | 2.55 | 3.28 | 2.70 | 2.43 | 2.08 |
| Combined SD (dB) | 6.10 | 5.93 | 5.66 | 4.92 | 5.33 | 4.99 | 4.85 | 4.68 |
| SEM (dB) | 1.30 | 1.23 | 1.20 | 1.07 | 1.16 | 1.02 | 1.11 | 1.02 |
| 95% confidence | 2.60 | 2.47 | 2.41 | 2.15 | 2.33 | 2.04 | 2.23 | 2.04 |
| p-values | 0.678 | 0.679 | 0.394 | 0.730 | 0.429 | 0.660 | 0.112 | 5.2*10^-4 |
| N | 22 | 23 | 22 | 21 | 21 | 24 | 19 | 21 |

*Tabel 1.*

The difference between the mean and median is less than 0.5 dB for all frequencies, which imply that the mean estimates are not largely affected by outliers. Figure 2 illustrates the mean difference D along with the confidence intervals from Table 1. Note that the confidence intervals have the measurement uncertainties from the standard included.

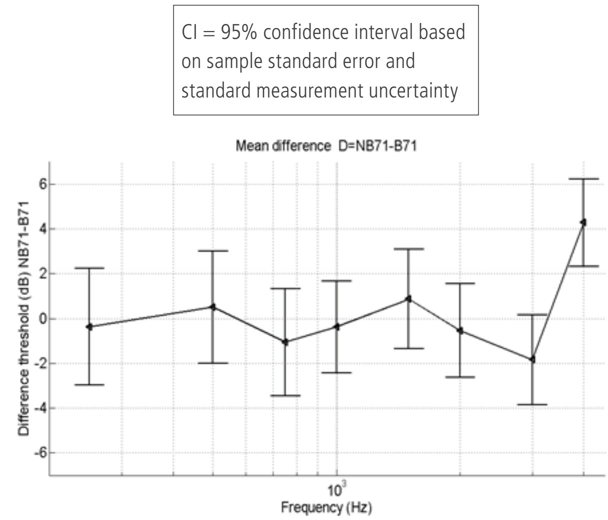


*Figure 2. Mean difference of BC-1 and B71. Error bars are 95% confidence intervals based on the standard errors, which are calculated by combining the sample standard error and standard measurement uncertainties. The graph illustrates how much BC-1 differs from B71. The results suggest that a significant difference between BC-1 and B71 exists for 4000 Hz as the confidence intervals do not cross zero.*

### Are the air-bone gaps obtained with B71 and BC-1 the same?

Results presented in the previous section show that there is a significant difference between the two bone vibrators at 4 kHz. Air-bone gaps also tell us how well the bone vibrators perform as the minimal air-bone gaps indicate that the bone vibrators perform and deliver accurate unbiased measures.

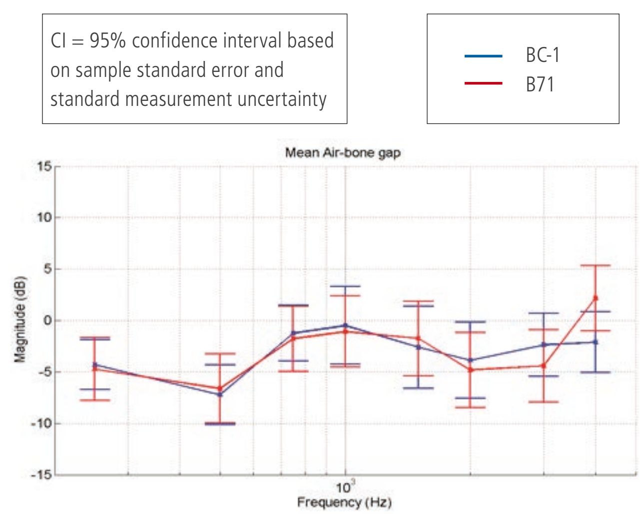


*Figure 3. Comparison of magnitude of B71 and BC-1 across the frequency range.*

The results presented in Figure 3 indicate that BC-1 and B71 perform largely the same – up to 2 kHz but deviates with 1.86 dB at 3 kHz and 4.22 dB at 4 kHz, which is also reflected in the mean difference graph (Figure 2). The confidence intervals overlap for all measured frequencies inferring that the air-bone gaps are not significantly different.

The general trend for BC-1 is flat across frequencies as opposed to B71, which has a positive notch at 4 kHz. Interestingly, the smallest air-bone gap is at 1 kHz, which is also the tone used to find the optimal position for the bone vibrator.

## Conclusion

BC-1 and B71 are identical for frequencies up to 2 kHz. For 3 kHz there is a 1.86 dB difference; however, BC-1 has smaller air-bone gap than B71, which suggests that it has a better conduction at this frequency. At 4 kHz, there is 4.22 dB difference between BC-1 and B71. The results show that in terms of air-bone gaps both bone vibrators have small air-bone gaps < 6 dB and with overlapping confidence intervals. At 4 kHz the results show that they are not significantly different. Since the direction of the air-bone gap for B71 at 4 kHz is positive and the confidence intervals are mostly positive it is likely to give rise to false-air bone gaps as reported in the literature. The BC-1, on the other hand, has a negative air-bone gap with the confidence intervals being mostly negative. Since the air-bone gaps for BC-1 at 4 kHz are similar to those found at the other frequencies, BC-1 is assumed to deliver a more reliable performance at all frequencies.

This study shows that the RETFLs in the standard ISO 389-3:1994 should be used with BC-1 and that the clinician can expect to obtain a more flat profile in terms of air-bone gaps.

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## Q&A

Q: Are there any changes to the cleaning/maintenance instructions of the BC-1 in comparison to B71?
A: No.

Q: Does this one comply with the standard?
A: Yes, the findings presented in this white paper and the data sheet demonstrate that.

Q: What about 6 and 8 kHz that are selectable in OTOsuite®?
A: BC-1 has been validated up to 4kHz

Q: What do I do if the cable breaks
A: Then the vibrator and cable will have to be exchanged. This is due to safety regulations related to the connection between the cable and the bone vibrator itself.

Q: Is it calibrated for speech?
A: BC-1 is as applicable for speech as B71

Q: Do I need to have my audiometer re-calibrated in order to use BC-1?
A: You should have your audiometer calibration verified because the bone vibrator has changed. If necessary, BC-1 is calibrated the same way as B71.

Q: Can I test at additional frequencies and at higher levels with BC-1?
A: No.

## References

*International standard ISO 8253-1, International standard ISO 389-3:1994, International standard ISO 389- part 3*

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*Margolis, R. H., Eikelboom, R. H., Johnson, C., Ginter, S. M., Swanepoel, D. W., & Moore, B. C. J. (2013). False air-bone gaps at 4 kHz in listeners with normal hearing and sensorineural hearing loss. International Journal of Audiology, 52(8), 526–32.*

*Lantz, Magnussen, Di Marco: Internal Study – RETFL for BC-1 (2015)*

*BC-1 – Technical Data Sheet*

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