# Biofeedback-Assisted Relaxation in Migraine Headache: Relationship to Cerebral Blood Flow Velocity in the Middle Cerebral Artery

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**Objective.—To determine if migraineurs with aura respond differently to biofeedback/relaxation than those without aura and, if so, whether the variability in outcome can be explained by blood flow velocity.**

**Background.—The relationship between cerebral blood flow velocity and treatment response to biofeedback/relaxation in migraine with and without aura is uncertain.**

**Method.—Twenty migraineurs underwent 12 sessions of biofeedback/relaxation therapy, while 20 controls simply were told to relax on their own. Cerebral blood flow velocity was measured bilaterally in the middle cerebral artery with transcranial Doppler.**

**Results.—The biofeedback group showed significant ($P < .05$) reductions in pain, depression, and anxiety compared to the control group. Patients with and without aura did equally well. There were significant ($P < .05$) left to right blood flow velocity differences only in the migraine with aura group. Maximum blood flow velocities were significantly higher ($P < .05$) in the migraine with aura group than in the cohort without aura. There was an inverse correlation between indicators of anxiety and blood flow velocity, perhaps related to hyperventilation-induced constriction in the small vessels distal to the middle cerebral artery.**

**Conclusion.—The positive treatment response to biofeedback/relaxation in migraine headache is not related to presence of aura, nor to changes in blood flow velocity, but may be associated with reduction in anxiety and depression.**

**Key words: migraine, cerebral blood flow, biofeedback, relaxation**

**Abbreviations: BFRT biofeedback-assisted relaxation, TCD transcranial Doppler, BFV blood flow velocity, MWA migraine with aura, MCA middle cerebral artery, MWOA migraine without aura**

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Medical and behavioral therapies are used in the treatment of headache with varying degrees of success. Past studies of behavioral interventions such as biofeedback-assisted relaxation (BFRT) have supported its efficacy in migraine and tension-type headache.[1-4] In migraine headache, thermal biofeedback and passive relaxation is more effective than relaxing without instructions or feedback.[5] Psychosocial factors, such as major life events and frequent hassles, presumably intensifying anxiety and depression have been associated with chronic headache.[6] Biofeedback-assisted relaxation is thought to exert its positive effects by facilitating the ability of patients to decrease sympathetic neural activity, and reduce depression and anxiety.

Transcranial Doppler (TCD) recordings have been used to explore ictal and interictal blood flow velocity (BFV) patterns in migraineurs. During attacks, those experiencing migraine with aura (MWA) showed increases in flow velocities and decreased

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pulsatility in the middle cerebral artery (MCA), while subjects without aura (MWOA) evidenced the reverse.[7] During the pain-free periods, BFV and pulsatility index remained higher than in normal controls. Flow velocity elevation may be due to increased vascular tone or narrowing of the insonated artery.[8-9]

Blood flow velocity has previously been assessed in studies of the effects of BFRT in migraine headache. Patients with higher BFV in the MCA seemed to be more successful at reducing pain levels than those patients with lower values. There were no similar findings in the basilar or ophthalmic arteries.[10] Nonetheless, patients were not stratified by type of migraine, and the relationship between flow velocity and standard indicators of psychological stress were not evaluated.

The goals of this study, therefore, were to confirm that migraine head pain is reduced more with BFRT than with simple relaxation, and to establish if the presence of aura affects outcome. Finally, assessment of the correlation between BFV and psychophysiological stress measures, such as heart rate, peripheral skin temperature, and self-reported anxiety, was planned.

## SUBJECTS AND METHODS

Fifty-five subjects with migraine headache, diagnosed by a physician according to International Headache Society criteria, volunteered to participate in the study. Exclusion criteria for the study were the presence in the patient history of anemia, or severe medical or psychiatric illnesses. At the first visit, subjects signed informed consent (previously approved by the Institutional Review Board). Fifteen subjects did not finish the study. Seven could not make the time commitment; 4 subjects did not keep appointments; 1 subject changed medication. Three were too ill to continue participation.

Forty subjects completed either the experimental (n = 20: 3 men, 17 women; mean age, 38 years [range, 20 to 53 years]) or control (n = 20: 2 men, 18 women; mean age, 39 years [range, 25 to 57 years]) arms of the study. Twenty-seven subjects had MWOA, while 12 had MWA; 1 was undetermined. Sex distribution, mean age, and number of years of headache were similar in subjects in the two groups.

Subjects used log sheets to record intensity, frequency, and duration of headaches and medication use (prescription and over the counter) throughout the study. During the 28 days prior to randomization (pretest) and 28 days after treatment or control (posttest), subjects underwent physiological, psychological, and cerebral BFV assessments.

Subjects completed a brief medical history questionnaire on their headache history, past treatment, other physical problems, and general health habits. Forehead muscle tension measurements were taken with a J & J electromyograph (EMG) set at a bandpass of 100 to 200 Hz. Finger temperature was recorded from the left index finger with a Biologic Device Thermograph. Data was averaged from two 5-minute intervals on separate occasions. Blood flow velocity was measured during the headache-free interval in the left and right MCA with a 2-MHz sensor at a depth of 50 to 55 mm by a TCD (Multi Dop, Elektronishe Systeme, Germany). The MCA was approached through the transtemporal window, the thinnest portion of the temporal bone. The following values were obtained: peak systolic velocity (Vs), peak diastolic velocity (Vd), and mean BFV (Vm). The left/right difference in Vs velocity was calculated.[11] Subjects' heart rates and peripheral skin temperature were recorded during TCD measurements. Anxiety (state and trait) and depression was assessed, once during pretest and once during posttest. State anxiety refers to anxiety experienced at the present time; trait anxiety is chronic, enduring anxiety.[12-13]

**Treatment.—**After the completion of the pretest phase, subjects were randomly assigned to one of two groups. The experimental group received 12 fifty-minute sessions of BFRT. Electromyograph feedback was provided during the first 4 sessions and thermal feedback was given during the last 8 sessions. Electromyograph feedback from the forehead muscles was incorporated because excessive contraction of facial and head muscles may intensify pain in migraine headache. Autogenic (passive) relaxation was taught to subjects at the first treatment session and practiced in subsequent sessions.[14] With the aid of EMG and thermal biofeedback, subjects were trained to decrease forehead muscle tension and to increase finger temperature.[15] Home practice consisting of 10 to 15

minutes twice daily was strongly encouraged. Tapes and scripts were provided for home practice.

Subjects in the control group were asked to relax on their own for 10 to 15 minutes twice daily and to concentrate on peaceful thoughts or on their breathing. No tapes or scripts were given. This group, called "self-relax." was seen twice during the 8- to 12-week period.

**Data Analysis.—**Pretest/posttest values of muscle tension, hand temperature, BFV, pain, and medication were analyzed using multivariate analysis of variance (MANOVA), two-way repeated measures (ANOVA), analysis of covariance (ANCOVA), *t* test for dependent samples, and Pearson correlation. In the analysis of group differences in outcome, interactions between period (pretest, posttest) and group (BFRT, self-relax) were explored. When the statistical interaction was significant, *t* tests were used to pinpoint whether the differences occurred between groups, over time, or both. Pain data was compiled as a headache index (average frequency, duration, and intensity of pain for the 28-day pretest and posttest period). Success was defined as a 50% reduction in pain score.[16] Medication use for migraine was averaged for the same time period. The number of pain-free days that occurred during pretest and posttest were counted and averaged.

## RESULTS

Table 1 shows the results of the repeated-measures ANOVA for headache index, medication index, and number of pain-free days. A significant interaction ($P = .046$) between group (BFRT and self-relax) and period (pretest/posttest) was observed, with the BFRT group as a whole showing a 39% reduction in head pain ($P = .0006$) in comparison to a nonsignificant 7.9% reduction in head pain in the self-relax group. Analysis of medication use and number of pain-free days showed no group differences. Both groups significantly reduced medication use ($P = .0007$) and increased the number of pain-free days ($P = .001$) between pretest and posttest (ie, over time).

Table 2 shows the results of ANCOVA of forehead muscle tension and temperature. A significant interaction ($P = .035$) between group and period was found for muscle tension. When pretest values were equalized statistically, the groups were different at posttest. There were no significant group differences in peripheral temperature.

Table 3 shows the results of repeated-measures ANOVA of depression, trait anxiety, and state anxiety. A significant interaction ($P = .039$) between group and period was observed in depression scores. The BFRT group showed a 56% reduction in self-reported depression ($P = .0002$) between pretest and posttest, whereas the decrease in the self-relax group was not significant. A significant group difference ($P = .02$) was observed in trait anxiety scores; only the BFRT group showed a significant reduction ($P = .0007$). A significant interaction ($P = .05$) was also observed in state anxiety scores; specifically, the BFRT group showed a 14% decrease in state anxiety ($P = .004$).

Table 4 shows the means and standard deviations at pretest and posttest for cerebral BFV. Values were

**Table 1.—Headache Index (Daily Pain Rating of Intensity, Frequency, and Duration for 1 Month Before Randomization and 1 Month After BFRT or Self-Relax)***

| Group | Pretest | Posttest | *P* |
|---|---|---|---|
| BFRT group | 0.53 (.31) | 0.32 (.30) | .046 |
| Control group | 0.51 (.42) | 0.47 (.43) | |

*Data are given as mean (SD). BFRT indicates biofeedback-assisted relaxation.

**Table 2.—Forehead Muscle Tension and Peripheral Skin Temperature***

| | Pretest | Posttest | *P* |
|---|---|---|---|
| Forehead EMG, μV | | | |
| BFRT group | 2.2 (0.8) | 1.5 (0.4) | .035 |
| Control group | 2.2 (1.1) | 1.8 (0.6) | |
| Temperature, °F | | | |
| BFRT group | 90.7 (5.3) | 91.9 (3.5) | |
| Control group | 89.2 (5.9) | 89.7 (6.18) | |

*Data are given as mean (SD). EMG indicates electromyograph; BFRT, biofeedback-assisted relaxation.

**Table 3.—Psychological Factors***

| | Pretest | Posttest | *P* |
|---|---|---|---|
| Beck Depression† | | | |
| BFRT group | 9.8 (5.6) | 4.3 (4.5) | .039 |
| Control group | 10.5 (9.9) | 8.9 (11.8) | |
| Trait anxiety† | | | |
| BFRT group | 40.4 (8.9) | 34.4 (8.9) | .02 |
| Control group | 36.8 (10.2) | 36.3 (12.5) | |
| State anxiety† | | | |
| BFRT group | 36.3 (9.4) | 30.6 (9.4) | .05 |
| Control group | 34.7 (8.5) | 33.8 (7.8) | |

*Data are given as mean (SD). BFRT indicates biofeedback-assisted relaxation.
†Raw scores.

**Table 5.—Comparison of Patients With Migraine With Aura and Without Aura***

| Variable | With Aura (n = 12) | Without Aura (n = 27) | *P* |
|---|---|---|---|
| Headache Index | .51 (.32) | .50 (.40) | NS |
| Trait anxiety | 38.3 (9.6) | 38.8 (10.0) | NS |
| Depression | 9.9 (8.3) | 9.6 (7.5) | NS |
| Maximum BFV, cm/sec | | | .049 |
| Left | 102.2 (14.2) | 90.9 (19.0) | |
| Right | 97.1 (11.6) | 94.2 (17.5) | |
| Left/right difference | 8.4 (4.3) | 5.5 (3.9) | .05 |

*Data are given as mean (SD). NS indicates not significant; BFV, blood flow velocity.

consistent with prior studies in patients with migraine, but there were no significant differences between the groups or between pretest and posttest.

Patients with MWA and MWOA were compared on the basis of pretest physiological and psychological characteristics and outcome (Table 5). There was no difference between MWA and MWOA in headache index, anxiety, or depression scores at pretest.

**Table 4.—Cerebral Blood Flow Velocity in Middle Cerebral Artery***

| | Left Side | Right Side |
|---|---|---|
| | Pretest | Posttest |
| Maximum velocity | | |
| BFRT group | 97.1 (16) | 98.1 (15) |
| Control group | 95.8 (18) | 99.4 (17) |
| Minimum velocity | | |
| BFRT group | 45.4 (8) | 45.7 (8) |
| Control group | 47.6 (8) | 44.0 (9) |
| Mean velocity | | |
| BFRT group | 62.7 (11) | 63.2 (10) |
| Control group | 64.5 (11) | 63.5 (12) |
| Pulsatility index | | |
| BFRT group | 0.80 (.1) | 0.84 (.1) |
| Control group | 0.83 (.2) | 0.87 (.1) |

*Data are given as mean (SD). BFRT indicates biofeedback-assisted relaxation.

Patients with MWA and MWOA had similar decreases in head pain index. There was, however, a significant group difference in maximum BFV and in left/right side difference in BFV. The patients with MWA had higher values of maximum BFV and larger left/right side BFV difference.

Pearson correlation was calculated between BFV and indicators of stress, namely trait anxiety score, heart rate, and peripheral temperature. As expected, trait anxiety and heart rate were positively correlated. Significant negative correlations ($P < .05$) were obtained between BFV, heart rate, and anxiety. Higher BFV was associated with lower values of both heart rate and anxiety.

## COMMENTS

The BFRT group evidenced larger decreases in the headache index and used less migraine medication than the self-relax group. This finding supports the superiority of BFRT over less intense, self-guided relaxation in reducing severity of pain, though not necessarily frequency of pain. Lower muscle tension levels after BFRT suggest that these subjects learned the relaxation techniques, while reductions in depression and anxiety in the same group suggests that BFRT lessened subjects' negative affect. We can speculate that the patients in the self-relax group who met criterion for success were highly motivated or had had some prior therapy. Minimal-therapist-contact

protocols have, in other clinics, shown positive results in patients with headache who were willing to practice the techniques independently.[17] The success rate in the BFRT and self-relax groups is similar to our previous studies of migraine.[5,10]

Transcranial Doppler provides information about the velocity of blood flow and allows inferences about cerebrovascular resistance. Thie et al discussed the presence of smaller-caliber vessels and a more reactive arterial tree in migraineurs regardless of aura.[7-8] In the current study, MWA exhibited higher BFV than MWOA regardless of head pain. However, the differences in BFV between MWA and MWOA cannot explain the improvement in the headache index in the BFRT group.

The relationships between BFV and psychophysiological indicators of stress permit speculation on the role of psychological factors in migraine. As expected, self-reported high anxiety was correlated with higher heart rates and lower hand temperatures. In addition, BFV was negatively correlated with heart rate and anxiety. It is well known that anxious patients often breathe at higher rates than controls or overtly hyperventilate. Hyperventilation is associated with significant decreases in BFV, while inhalation of 5% $CO_2$ produces increases in BFV.[18] Exacerbations of anxiety during migraine attack reflected in blood pressure and heart rate could not be demonstrated, since these variables were assessed during migraine-free periods. Zanette et al,[19] however, reported that blood pressure and heart rate were consistent during migraine attacks and pain-free periods. Biofeedback-assisted relaxation was associated with decreases in BFV in an earlier study, but this was not presently replicated, perhaps due to different TCD measurement conditions or to inter-rater variability.

Further studies are needed to clarify the relationship between BFV and anxiety and to determine, under precisely controlled conditions, whether changes in BFV parallel improvements in pain after pharmacological and behavioral intervention. Personality characteristics and coping styles of patients that respond positively to BFRT and to simple relaxation should be explored further, using a tool such as the Millon Behavioral Health Inventory.[20]

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