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ORIGINAL ARTICLE - NEUROSURGERY GENERAL

Surgical decompression of arachnoid cysts leads to improved quality of life: a prospective study—long-term follow-up

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Abstract

Background In a previous study, we reported a short-term (6 months) postoperative improvement of health-related quality of life (Qol) in patients operated for an arachnoid cyst (AC). The aim was to investigate whether this initial improvement was permanent.

Methods A long-term (5 ± 2 years) prospective study comparing Qol and complaints before and 5 ± 2 years after surgical fenestration for AC in 76 adult patients, using the Short Form 36 (SF-36) scores, Glasgow Benefit Inventory (GBI) questionnaires, and Visual Analogue Scales (VAS) for headache and dizziness, similarly to what they did at short-term follow-up.

Results At short-term and long-term follow-ups, 73.4% and 82%, respectively, of the patients were better from their headache compared with preoperative scores. The corresponding improvement rates for dizziness were 61.7% (short-term) and 67.9 (long-term). Preoperatively, the mean headache VAS score was 45.6; at short-term follow-up, this was reduced to 25.7, and at long-term follow-up, this further reduced to 24.8. The preoperative mean VAS score for dizziness (35.2) was reduced to 12.2 (short-term) and 13.9 (long-term). The significant postoperative improvement of patient-reported Qol at short-term follow-up remained at long-term follow-up across seven out of eight SF-36 dimensions and three out of four GBI subscale scores. Similar to at short-term follow-up, the Qol improvement is correlated to improvement in headache and/or dizziness.

Conclusions The previously reported postoperative, short-term improvement in Qol and complaints appears stable, as the improvement remains at long-term follow-up. This suggests that the beneficial effects of surgical treatment are long-lasting.

Keywords Arachnoid cyst · Surgical treatment · Prospective study · Quality of life · Health status · Headache · Dizziness · Volume · Long-term follow-up

Abbreviations

AC	Arachnoid cyst
CNS	Central nervous system
GBI	Glasgow Benefit Inventory
Qol	Quality of life
VAS	Visual Analogue Scale

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Introduction

Arachnoid cysts (ACs) are congenital malformations of the arachnoid layer covering the central nervous system (CNS) [2, 3, 34]. They are most often asymptomatic, but may cause neurological deficits such as seizures, or non-specific symptoms such as headache, impaired cognition, or dizziness [10, 13, 15, 22, 27, 28, 31–33].

Various surgical techniques have been used to fenestrate the wall of ACs, creating communication with the normal subarachnoid space [1, 4, 7, 8, 11, 12, 14, 21, 23, 26, 29, 30], but surgical treatment of these cysts has remained controversial [13, 14, 16, 25, 26].

In previous prospective and retrospective studies, our group has reported that surgical decompression of AC can be performed with a relatively low risk and that it yields significant improvement of complaints and patient-reported quality of life on a short-term basis [12–14, 17].

The aim of the present study was to determine whether this postoperative improvement in quality of life (Qol) is permanent and stable and if there had been any change in Qol from short-term to long-term follow-up. We therefore re-examined the patient cohort that was included in our previous prospective study [17], approximately 6 years after surgery.

Methods

This is a prospective long-term follow-up study of the patients included in our previous study [17]. The included patients, see below, were followed up 5 ± 2 (mean 6) years after surgery.

Inclusion

A total of 154 adult patients were referred to our department with a newly diagnosed intracranial AC. Of these, 58 patients had minor complaints and no clear indication for surgery. Ninety-six adult patients had significant symptoms and were offered surgery. Six of them declined surgery despite severe symptoms. Eight of these 90 patients received a cystosubdural shunt, whereas 82 were operated with craniotomy and fenestration of the cyst; these were invited to participate in the present study, and 76 of these consented and were included in the study.

All the 76 patients enrolled in our previous study had responded to the preoperative questionnaires. Of these, nine were lost to follow-up and two died from unrelated causes during the study period, thus 67 and 65 Qol questionnaires (Short Form 36 [SF-36] and Glasgow Benefit Inventory [GBI]) were accessible for pre- and long-term comparative analysis, respectively. Sixty-four headache and dizziness VAS scores were accessible for pre- and long-term comparative analysis. A comparison between the 11 patients lost to follow-up and the remaining study cohort revealed no significant differences in baseline demographics, questionnaire scores, and cyst volumes (for a summary of patients and cyst characteristics, see our previous publication [17]).

Surgery

All patients underwent a craniotomy under general anaesthesia. During this procedure, the parietal cyst membrane covering the inside of the dura was peeled off the dura and then removed from its attachment to the surrounding cortex, for temporal cysts all the way to the tentorial slit. The membrane that covered the brain surface (the visceral membrane) was not removed. Small bridging veins running for some distance along the parietal membrane before they drained into the basal sinuses were coagulated and removed with the parietal membrane. Large bridging veins near the sphenoid ridge, running for only a very short distance along the membrane before draining were not extirpated. The medial, remaining membrane, covering the basal structures (the tentorial slit, the oculomotor nerve, the carotid artery, and the optic nerve) was fenestrated, thus creating communication to the basal cisterns and the posterior fossa. When accessible, the arachnoid covering the Sylvian fissure was also opened.

Ethical approval

Ethical approval was obtained from the Norwegian regional ethics committee of Health Region West, and written informed consent was given by all participants according to the Declaration of Helsinki.

Questionnaires

For details regarding the questionnaires that were used, see our previous article [17].

SF-36

The SF-36 is a generalized survey of patient health consisting of 36 questions yielding eight scaled subscores, each reflecting a dimension of health and is the weighted sum of specified questions within the questionnaire transformed to a scale ranging from 0 to 100, where a higher score indicates a better health status.

The subscores in SF-36 are as follows: physical function (pf), role physical (rp), bodily pain (bp), general health (gh), vitality (vt), social function (sf), role emotional (re), and mental health (mh).

VAS

TheVAS is a simple and sensitive method for estimating the intensity of various chronic pain conditions, including headache and has also been validated for use in visual vertigo or dizziness. As an adjunct to Qol questionnaires, we used VAS for quantifying pre- and postoperative intensity for headache and dizziness. In this study, VAS questionnaires comprised five (headache) and three (dizziness) symptom-directed questions.

Glasgow Benefit Inventory forms

At short-term and long-term follow-ups, the patients completed GBI questionnaires, which is a survey designed to measure the effect of an intervention on the patient's health status. It consists of 18 questions; the response to each question is based on a 5-point Likert scale ranging from a large deterioration to a large improvement in health status. The GBI questionnaire is evaluated by calculating a total score (Tot), a general subscale score (Gss), a social support subscale score (Sss),

Table 1 Preoperative, postoperative, and long-term headache and dizziness characteristics

Preoperative headache	***n* (%)**	**Postoperative headache**	***n* (%)**	**Long-term follow-up headache**	***n* (%)**
Headache last 3 months					
None	10 (13.2)	None	18 (28.1)	None	21 (31.3)
Constant	28 (36.8)	Constant	9 (19.6)	Constant	8 (11.9)
Periods	34 (44.7)	Periods	25 (53.4)	Periods	25 (37.3)
Attacks	28 (36.8)	Attacks	14 (30.4)	Attacks	17 (25.4)
Last week	3.5 (3.7)	Last week	2.5 (2.0)	Last week	4.8 (10.0)
Last 3 months	49 (110)	Last 3 months	8.6 (9.5)	Last 3 months	20.2 (31.9)
Headache quality					
Pulsating	25 (32.9)	Pulsating	9 (19.6)	Pulsating	12 (17.9)
Constant pressure	48 (62.3)	Constant pressure	33 (71.7)	Constant pressure	28 (41.8)
Stinging/burning	20 (26.3)	Stinging/burning	10 (21.7)	Stinging/burning	10 (14.9)
Other	9 (11.8)	Other	9 (19.6)	Other	1 (1.5)
Headache diurnal variation					
No variation	19 (25.0)	No variation	19 (41.3)	No variation	13 (19.4)
Variation	49 (64.4)	Variation	27 (58.7)	Variation	26 (38.8)
Worst morning	13 (26.5)	Worst morning	8 (29.6)	Worst morning	8 (11.9)
Worst daytime	17 (34.7)	Worst daytime	12 (44.4)	Worst daytime	8 (11.9)
Worst evening	22 (44.9)	Worst evening	11 (23.9)	Worst evening	15 (22.4)
Preoperative dizziness	***n* (%)**	**Postoperative dizziness**	***n* (%)**	**Long-term follow-up dizziness**	***n* (%)**
Dizziness last 3 months					
None	22 (29.8)	None	40 (62.5)	None	14 (20.9)
Constant	13 (17.1)	Constant	2 (8.3)	Constant	4 (6.0)
Periods	38 (50.0)	Periods	14 (58.3)	Periods	15 (22.4)
Attacks	21 (27.6)	Attacks	9 (37.5)	Attacks	10 (14.9)
Last week	4.4 (6.5)	Last week	2.8 (3.5)	Last week	5.5 (10.0)
Last 3 months	44 (84)	Last 3 months	6.8 (6.3)	Last 3 months	19.6 (31.4)
Dizziness quality					
Carousel type	17 (31.5)	Carousel type	4 (16.7)	Carousel type	8 (11.9)
Boat deck type	32 (59.3)	Boat deck type	13 (54.2)	Boat deck type	12 (24.0)
Floating/walking on pillows	5 (9.3)	Floating/walking on pillows	5 (20.8)	Floating/walking on pillows	5 (17.9)
Sudden falls	6 (11.1)	Sudden falls	1 (4.2)	Sudden falls	7 (10.4)
Other	12 (22.2)	Other	11 (45.8)	Other	3 (4.5)

and a physical health subscale score (Phs). Possible scores range from − 100 to + 100, indicating a negative or positive change.

Statistical analyses

Data was analyzed using Excel (Microsoft, Redmond, WA, USA) and SPSS 20/21 (IBM, Armonk, NY, USA). If not otherwise stated, data is reported as averages ± one standard deviation. For comparison of pre- and postoperative scores, we used a paired Student *t* test. The general significance level was set to 0.05.

To investigate the association between quality of life and improvement in headache, dizziness, or radiological improvement, we used a linear regression model in SPSS. We performed both multivariate and univariate analyses to determine existing correlations between predictors (headache, dizziness, and sex) and patient health status as measured by improvement in SF-36 scores and positive GBI scores. Baseline SF-36 scores were checked for correlation.

Results

A total of 67 patients answered the long-term questionnaires, 35 males (52.2%) and 32 females (47.8%). The mean age was 52.1 (range 20–88 years).

Preoperative findings

Prior to surgery, 73 of the 76 patients (96.1%) reported some kind of subjective complaints: 64 patients had headache and

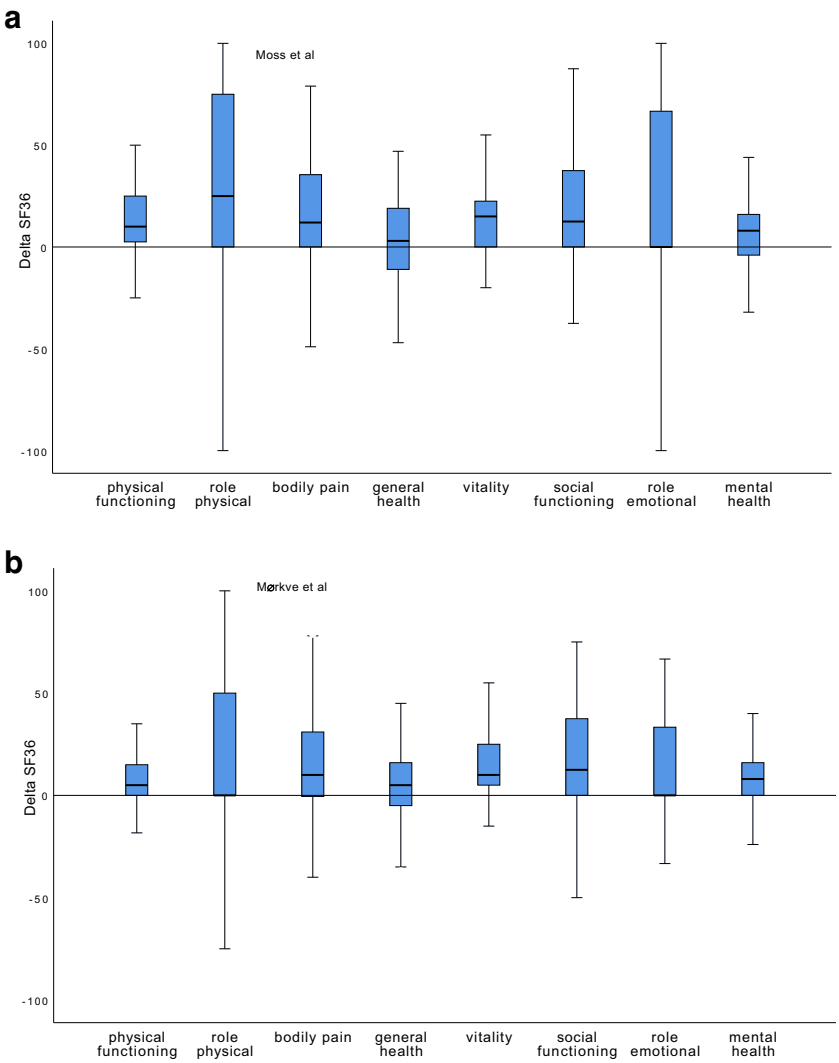

Fig. 1 Long-term postoperative improvement in Qol—SF-36. **a** Box plots showing long-term delta SF-36 scores (postoperative long-term follow-up scores minus preoperative scores) for all eight SF-36 dimensions. The mean standard score for postoperative improvement was as follows: *pf* from 75.0 to 87.6, *rp* from 34.7 to 65.1, *bp* from 47.0 to 63.8, *gh* from 58.2 to 62.7, *vt* from 35.7 to 48.3, *sf* from 57.2 to 74.6, *re* from 50.2 to 77.1, and *mh* from 63.7 to 71.3. **b** Box plots showing postoperative short-term delta SF-36 scores (postoperative short-term scores minus preoperative scores) for all eight SF-36 dimensions [17]. The mean standard score improvement after surgery is noted above each box plot and was as follows: *pf* from 75.0 to 84.5, *rp* from 34.7 to 54.0, *bp* from 47.0 to 61.6, *gh* from 58.2 to 67.3, *vt* from 35.7 to 51.1, *sf* from 57.2 to 76.2, *re* from 50.2 to 73.1, and *mh* from 63.7 to 72.9. **a**, **b** Boxes represent values from 25 to 75 percentiles and median values are marked as lines within the boxes. Error bars indicate 95% confidence intervals

53 patients reported dizziness (for preoperative characteristics of headache and dizziness, see Table 1).

Quality of life measures

SF-36 scores: comparison between preoperative and long-term follow-up scores

In the long-term follow-up, we found highly significant improvements from the preoperative scores across all norm-based SF-36 dimensions (all p values < 0.008, paired samples t test, $n = 58–65$, F 1), except for general health (gh, $p = 0.117$) (see Fig. 1).

SF-36: comparison to healthy control group

The short-term follow-up study indicated that the Qol after surgery matched that of an age-stratified population average for all SF-36 dimensions [17]. At long-term follow-up, we found that the Qol mathced that of the same population average in six out of eight SF-36 dimensions (rp, bp, gh, vt, sf, mh) (all $p < 0.05$, independent samples t test, $n = 55–58$).

SF-36: comparison between short-term and long-term follow-up scores

Comparing the short-term follow-up and long-term follow-up for all subscale scores of SF-36, we found highly significant improvements for all dimensions (all $p < 0.05$, paired samples t test, $n = 48–52$). Thus, there appeared to be a continuing Qol improvement after the short-term follow-up.

Glasgow Benefit Inventory scores at long-term follow-up

Long-term total GBI scores were positive with mean improvements ranging from + 0.14 to + 15.25, indicating a long-lasting improved patient health status. The mean

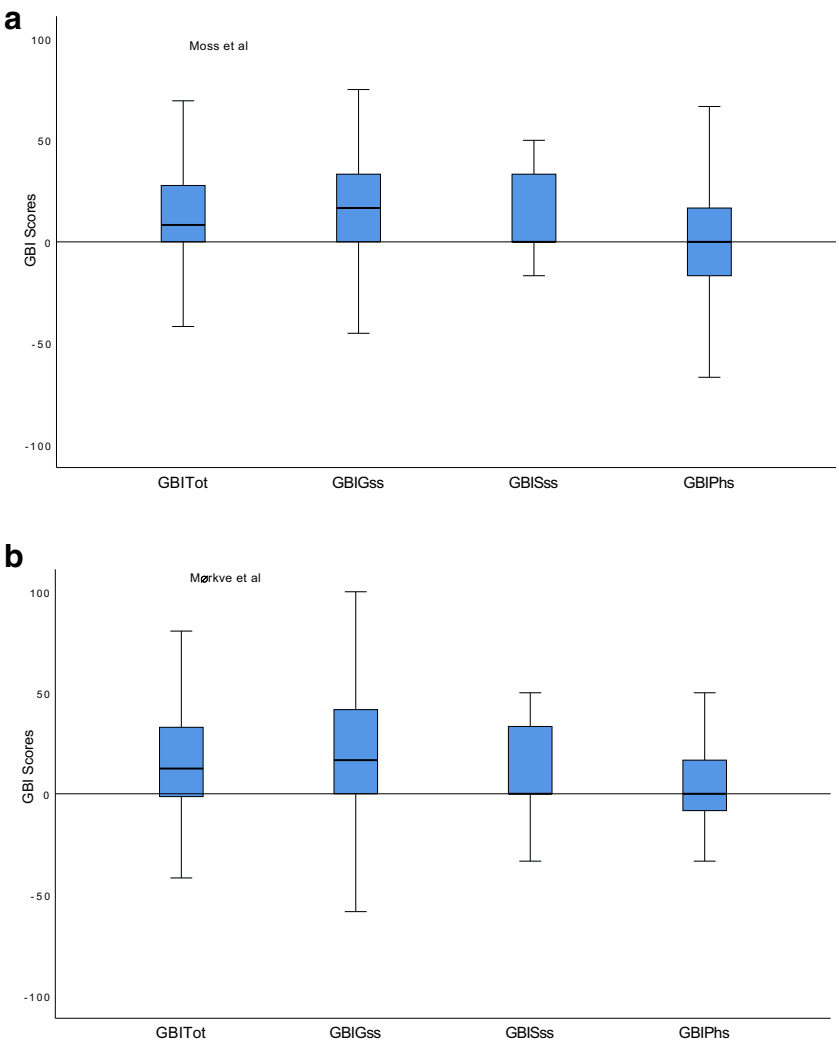

Fig. 2 Improvement in Qol following surgery—GBI. **a** Box plots showing GBI total and subscale scores at long-term follow-up. Mean scores were as follows: *Tot* + 12.4 ± 27.84, *Gss* + 15.2 ± 32.86, *Sss* + 10.6 ± 24.74, and *Phs* + 0.1 ± 32.2. **b** Box plots showing GBI total and subscale scores at short-term follow-up[27]. Mean scores were as follows: *Tot* + 15.8, *Gss* + 19.3, *Sss* + 13.5, and *Phs* + 4.2. **a**, **b** Boxes represent values from 25 to 75 percentiles and median values are marked as lines within the boxes. Error bars indicate 95% confidence intervals

scores were all significantly higher than 0 (Fig. 2), except for the physical health subscale (Phs) score ($p < 0.001$, one-sided t test).

GBI: comparison between short-term and long-term follow-up scores

We found no significant difference in GBI scores at long-term versus short-term follow-up ($p > 0.05$, paired samples t test, $n = 61$).

VAS scores

Headache

The mean preoperative headache VAS score was 45.6 ± 25.8. There was a significant reduction in headache scores at short-term follow-up after surgery to 25.7 ± 23.5 (n = 64). At long-term follow-up, the VAS score for headache was 24.8 ± 26.6 ($n = 61$) (Fig. 3). In 45 patients, the follow-up headache VAS scores were reduced (improved) by a mean of 31.8 when compared with their preoperative scores, and in eight patients, there was no change and the mean VAS scores increased by a mean of 10.0 in the remaining eight patients.

Dizziness

The mean preoperative dizziness VAS score was 35.2 ± 31.2. There was a significant reduction in dizziness scores at short-term follow-up after surgery to 12.2 ± 20.1 (n = 64). At long-term follow-up, the mean dizziness VAS score was 13.9 ± 22.8, ($n = 59$) for dizziness (Fig. 3). In 39 patients, the follow-up dizziness VAS scores were reduced (improved) by a mean of 47.3 when compared with their preoperative scores, and in eight patients, there was no change and the mean VAS scores increased by a mean of 25.2 in the remaining 12 patients.

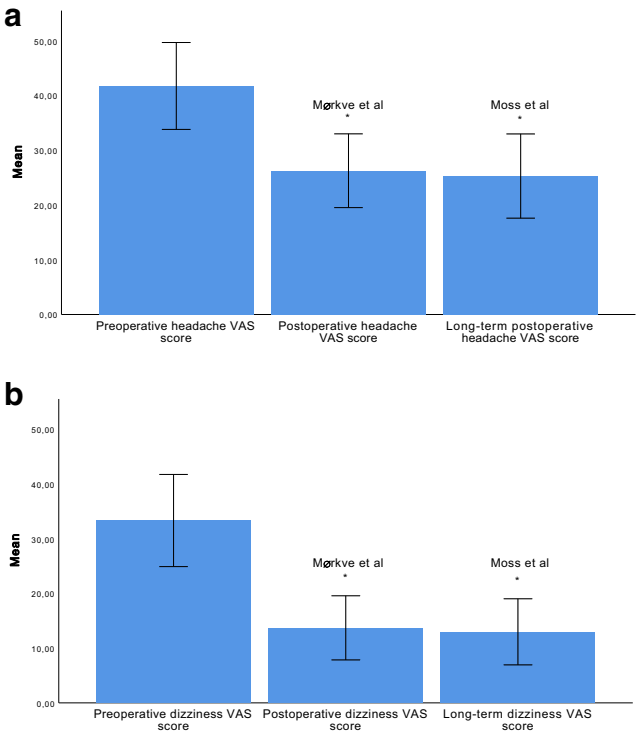

Fig. 3 Permanent improvement in headache and dizziness and following surgery. **a** Headache VAS scores. Bar diagram showing the average of mean patient-reported preoperative (45.6 ± 25.8, $n = 76$), postoperative short-term (25.7 ± 23.5, $n = 64$) [17], and long-term follow-up (25.7 ± 23.5 ($n = 64$)) headache VAS scores. **a**, **b** Error bars signify one standard deviation, and asterisk symbol above postoperative bar signifies a statistically significant improvement (all $p < 0.0001$). **b** Dizziness VAS scores. Bar diagram showing average of patient-reported preoperative (35.2 ± 31.2, $n = 76$), postoperative short-term (12.2 ± 20.1, $n = 64$) [17], and long-term follow-up (13.9 ± 22.8, $n = 59$) dizziness VAS scores

Correlation between improvement in Qol and improvement of complaints at long-term follow-up

SF-36 long-term follow-up scores

We analyzed the possible impact of improvement in headache and dizziness, patient's age, and sex on the improvement as reflected in the SF-36 subscale scores. Linear regression was performed between mean headache and dizziness VAS change, patient's sex, and age versus all postoperative delta SF-36 subscale scores using both multivariate and univariate analysis models (ANOVA). Results are summarized in Table 2.

We found that a reduction in headache or dizziness is related to an improvement in the SF-36 *rp* and *bp* subscale scores using multivariate regression analysis ($p =$ 0.041 to 0.026), and in all dimensions except from the *re* subscale using univariate regression analysis ($p =$ 0.026 to 0.007). Gender and age did not correlate with the SF-36 scores.

At short-term follow-up, we found a correlation between a reduction in headache or dizziness in six out of eight SF-36 dimensions [17].

GBI long-term follow-up scores

A linear regression analysis was performed between mean headache and dizziness VAS change, patient sex, and age versus all GBI subscale scores using both multivariate and univariate models (ANOVA). Results are summarized in Table 3.

We found a significant correlation between improvement in headache and the GBI Phs subscale score using both multivariate ($p = 0.038$) and univariate ($p = 0.014$) analyses. A reduction in headache was related to an increase in the GBI Phs subscale score. There was no other correlations between predictors and any of the other GBI subscale scores.

We checked all predictors (headache, dizziness, patient age, and sex) for signs of multicollinearity or significant covariance. The preoperative mean headache and dizziness VAS scores showed significant correlation with a Pearson correlation coefficient of 0.941 ($p < 0.001$), but there was no significant covariance between other preoperative predictors. Similarly, there was a significant correlation between reductions in the mean headache VAS score and mean dizziness VAS score following surgery with a Pearson's correlation coefficient of 0.443 ($p =$ 0.001), which may explain some of the difference in correlation coefficients between our multivariate and univariate analysis models. There was no other covariance of predictors in our material.

Patient contentment with surgery

On long-term follow-up, we added a form regarding patient contentment with surgical decompression of the cyst. Fifty-nine patients responded to this questionnaire. Fifty-four patients (91.5%) were satisfied with the surgery, while five patients (8.5%) were not satisfied with the choice.

Discussion

Key results

The present study is the first to report prospectively on long-term results after surgical decompression of AC in a relatively large cohort (76 patients) of adults.

At follow-up 5 ± 2 years after surgery, we found a significantly improved Qol as measured with the Short Form 36 (SF-36) and to a lesser degree with the Glasgow Benefit Inventory

Table 2 Linear regression analysis showing correlation between delta SF-36 scores and change in predictors

Outcome variable, predictor	*B*	Multivariate analysis (95% CI)	$n = 53$, *p* value	*n*	*B*	Univariate analysis (95% CI)	*p* value
Delta SF-36pf							
Headache change	− 0.056	− 0.270, 0.157	0.598	58	0.004	− 0.221, 0.228	0.974
Dizziness change	− 0.058	− 0.205, 0.090	0.434	55	8.304	− 0.338, − 0.048	*0.010*
Age	− 0.276	− 0.580, 0.028	0.074	58	− 0.139	− 0.509, 0.231	0.455
Sex	− 1.123	− 9.767, 7.522	0.795	58	1.059	− 9.811, 11.928	0.846
Preop. SF-36pf	− 0.609	− 0.826, − 0.392	*0.000*[b]	55	− 0.599	− 0.784, − 0.414	*0.000*[b]
Delta SF-36rp							
Headache change	− 0.527	− 0.989, − 0.065	*0.026*	58	− 0.698	− 1.197, − 0.200	*0.007*[b]
Dizziness change	− 0.049	− 0.371, 0.272	0.759	55	− 0.452	− 0.796, − 0.108	*0.011*
Age	− 0.748	− 1.449, − 0.048	*0.037*	58	− 0.377	− 1.252, 0.498	0.392
Sex	− 15.844	− 35.863, 4.175	0.118	58	− 19.793	− 45.007, 5.422	0.122
Preop. SF-36rp	− 0.693	− 0.963, − 0.424	*0.000*[b]	58	− 0.723	− 0.984, − 0.461	*0.000*[b]
Delta SF-36bp							
Headache change	− 0.317	− 0.620, − 0.013	*0.041*	58	− 0.347	− 0.633, − 0.061	*0.018*
Dizziness change	0.014	− 0.195, 0.223	0.896	55	− 0.171	− 0.372, 0.030	0.093
Age	− 0.130	− 0.585, 0.326	0.570	58	0.013	− 0.484, 0.511	0.957
Sex	− 8.671	− 21.824, 4.483	0.191	58	− 6.692	− 21.141, 7.756	0.358
Preop. SF-36bp	− 0.497	− 0.759, − 0.235	*0.000*[b]	60	− 0.494	− 0.735, − 0.253	*0.000*[b]
Delta SF-36gh							
Headache change	− 0.016	− 0.351, 0.319	0.925	57	− 0.172	− 0.489, 0.145	0.283
Dizziness change	− 0.137	− 0.376, 0.101	0.253	54	− 0.264	− 0.472, − 0.057	*0.013*
Age	− 0.016	− 0.514, 0.482	0.949	57	− 0.038	− 0.568, 0.492	0.887
Sex	− 3.968	− 18.434, 10.498	0.584	57	− 3.780	− 19.251, 11.691	0.626
Preop. SF-36gh	− 0.491	− 0.813, − 0.170	*0.003*[b]	59	− 0.569	− 0.844, − 0.293	*0.000*[b]
Delta SF-36vt							
Headache change	− 0.213	− 0.464, 0.037	0.093	57	− 0.304	− 0.545, − 0.063	*0.015*
Dizziness change	0.026	− 0.158, 0.210	0.777	54	− 0.190	− 0.357, − 0.023	*0.026*
Age	0.055	− 0.318, 0.428	0.769	57	0.016	− 0.406, 0.438	0.940
Sex	− 0.935	− 11.816, 9.869	0.857	58	0.380	− 11.953, 12.712	0.952
Preop. SF-36vt	− 0.596	− 0.899, − 0.293	*0.000*[b]	59	− 0.624	− 0.874, − 0.373	*0.000*[b]
Delta SF-36sf							
Headache change	− 0.243	− 0.551, 0.065	0.119	58	− 0.344	− 0.644, − 0.044	*0.025*
Dizziness change	− 0.058	− 0.271, 0.155	0.583	55	− 0.238	− 0.443, − 0.033	*0.024*
Age	0.027	− 0.431, 0.485	0.906	58	0.072	− 0.447, 0.590	0.783
Sex	2.898	− 10.465, 16.261	0.665	58	5.472	− 9.640, 20.584	0.471
Preop. SF-36sf	− 0.527	− 0.784, − 0.270	*0.000*[b]	60	− 0.577	− 0.807, − 0.346	*0.000*[b]
Delta SF-36re							
Headache change	− 0.091	− 0.574, 0.391	0.705	58	− 0.404	− 0.959, 0.151	0.150
Dizziness change	− 0.063	− 0.383, 0.257	0.693	55	− 0.208	− 0.592, 0.176	0.282
Age	0.189	− 0.524, 0.903	0.596	58	0.366	− 0.564, 1.297	0.434
Sex	− 0.729	− 21.465, 20.008	0.944	59	− 6.284	− 33.592, 21.028	0.648
Preop. SF-36re	− 0.815	− 1.054, − 0.577	*0.000*[b]	60	− 0.835	− 1.046, − 0.624	*0.000*[b]
Delta SF-36mh							

Table 2 (continued)

Outcome variable, predictor	*B*	Multivariate analysis (95% CI)	$n = 53$, *p* value	*n*	*B*	Univariate analysis (95% CI)	*p* value
Headache change	− 0.219	− 0.471, 0.033	0.088	57	− 0.320	− 0.563, − 0.076	*0.011*
Dizziness change	0.013	− 0.156, 0.181	0.880	54	− 0.131	− 0.305, 0.042	0.136
Age	0.048	− 0.326, 0.423	0.796	57	− 0.030	− 0.457, 0.398	0.890
Sex	− 1.222	− 12.053, 9.609	0.821	57	− 3.568	− 16.034, 8.898	0.569
Preop. SF-36mh	− 0.637	− 0.933, − 0.341	*0.000*[b]	59	− 0.688	− 0.953, − 0.424	*0.000*[b]

Results of linear regression using multivariate and univariate analysis models of difference in predictors (headache change and dizziness change), sex, and age versus SF-36 dimension difference scores (delta SF-36 scores). Difference scores were calculated by subtracting postoperative scores from preoperative scores for predictors and SF-36 scores. Significant correlations are indicated in italics ($p < 0.05$), and highly significant correlations by "b" ($p < 0.001$). Short Form 36 (SF-36) dimensions: *pf* physical function, *rp* role physical, *bp* bodily pain, *gh* general health, *vt* vitality, *sf* social function, *re* role emotional, *mh* mental health

(GBI). Moreover, we have demonstrated a correlation between improvement in dizziness and headache and improved QoL.

A total of 82.0% of the patients improved from their headache, 9% worsened, and 9% remained unchanged (considered as less than 5-point change in average VAS scores). The corresponding long-term results for dizziness were that 67.9% improved, 19.6% worsened, and 12.5% of the patients remained unchanged. These findings are in accordance with our group's previous findings [17], giving the patients a probability ratio of 3–4 for improvement rather than worsening after surgery.

Quality of life

The patients' long-term postoperative improvement in QoL scores may be explained solely by the postoperative symptomatic relief in headache and dizziness. However, as discussed in our previous study on the short-term effect of cyst decompression, we cannot rule out other, more subtle effects of the cyst as causes for the preoperative QoL reduction and the postoperative improvement. We have previously shown that temporal cysts may impair cognition and that cyst decompression restores cognition [9, 15, 22, 27, 31, 33], and other studies have demonstrated reduced temporal lobe volume and reduced metabolism and perfusion in the cortex adjacent to the cyst, and that these changes normalize after cyst decompression [5, 24, 35], paralleling the postoperative cognitive improvements in the same patients [5, 24]. Thus, it appears reasonable to assume that the impaired, preoperative cognition and the postoperative recovery may have influenced both the preoperative impairment and the postoperative QoL improvement in our patients.

Placebo and long-term follow-up

As discussed in our previous report on the short-term effects [17], there is a risk of the results being affected by placebo effects. Cyst decompression is mostly undertaken to alleviate subjective symptoms; it is therefore possible that patients, seeking justification for their decision to undergo surgery, will exaggerate any positive effect an operation might have had. There is also a possible selection bias; patients opting for surgical treatment are likely to have a high degree of confidence in what they can obtain from the operation before treatment. Our department has relatively large experience with vestibular schwannoma patients [19, 20]. Like AC patients, vestibular schwannoma patients score preoperatively below average on the SF-36 questionnaire, mainly because of the vertigo and dizziness. The symptoms of vestibular schwannoma patients are also mainly subjective, but they did not show any postoperative improvement in SF-36 scores, whereas our AC patients experienced significant

Table 3 Linear regression analysis showing correlation between GBI scores and change in predictors

Predictor	*B*	Multivariate analysis (95% CI)	$n = 51$, p value	n	*B*	Univariate analysis (95% CI)	p value
GBI Tot							
Headache change	− 0.274	− 0.654, 0,105	0.152	58	− 0.270	− 0.580, 0.041	0.087
Dizziness change	0.002	− 0.250, 0.255	0.985	55	− 0.076	− 0.294, 0.141	0.484
Age	0.026	− 0.540, 0.591	0.927	58	0.071	− 0.456, 0.598	0.788
Sex	− 2.860	− 19.744, 14.024	0.735	58	− 1.655	− 17.088, 13.758	0.830
GBI Gss							
Headache change	− 0.344	− 0.807, 0.119	0.142	58	− 0.328	− 0.707, 0.051	0.089
Dizziness change	0.019	− 0.290, 0.327	0.904	55	− 0.080	− 0.346, 0.186	0.551
Age	0.053	− 0.638	0.743	58	0.110	− 0.534, 0.753	0.734
Sex	− 0.214	− 20.733, 20.486	0.990	58	1.324	− 17.508, 20.155	0.889
GBI Sss							
Headache change	0.093	− 0.308, 0.494	0.644	58	0.063	− 0.265, 0.391	0.703
Dizziness change	− 0.054	− 0.321, 0.213	0.687	55	− 0.030	− 0.255, 0.195	0.792
Age	− 0.142	− 0.739, 0.456	0.636	58	− 0.160	− 0.702, 0.381	0.556
Sex	0.031	− 17.801, 17.863	0.997	58	0.039	− 15.853, 15.932	0.996
GBI Phs							
Headache change	− 0.359	− 0.698, − 0.021	*0.038*	58	− 0.364	− 0.653, − 0.076	*0.014*
Dizziness change	− 0.006	− 0.232, 0.219	0.955	55	− 0.111	− 0.317, 0.096	0.288
Age	0.062	− 0.443, 0.566	0.807	58	0.123	− 0.380, 0.625	0.627
Sex	− 15.662	− 30.724, − 0.600	*0.042*	58	− 14.395	− 28.622, − 0.169	*0.047*

Results of linear regression using multivariate and univariate analysis models of difference in predictors (headache change and dizziness change), sex, and age versus GBI scores. Difference scores for predictors are the same as those for the Short Form 36 analyses. Significant correlations indicated in italics ($p < 0.05$). Glasgow Benefit Inventory (GBI) subscales: *Tot* total score, *Gss* general subscale score, *Sss* social support subscale score, *Phs* physical health subscale score

postoperative symptomatic relief and improvement in Qol. This difference between patient groups argues against bias from having gone through surgery and supports the notion that the improvement in fact is caused by the operation.

The fact that our patients reported an additional long-term improvement in Qol from the short-term follow-up makes it even less likely that placebo has played any major role, as it seems rather unlikely that placebo has such long-term effects [6, 18].

Limitations and strengths

As discussed in our short-term report, the most important limitation of our study is the lack of conservatively managed patients as controls. However, our conservatively managed patients were not suitable as controls, as their preoperative complaints were much less severe than those constituting the indication for surgery in the operated patients.

As cyst decompression is not a life-saving procedure, it is crucial that patients receive thorough and unbiased preoperative information about both risks and benefits of the procedure, in order to enable them to decide whether their symptoms are debilitating enough to accept the risks of undergoing this surgery. We also believe that patients with significantly increased surgical risks due to comorbidity should not be operated upon, except after careful consideration, and then perhaps with less invasive methods [11].

Conclusion

The long-lasting improvement of patient symptoms and Qol after surgical cyst decompression makes it less probable that the decrease in symptoms and increase in Qol could be a matter of placebo.

The data presented in this study suggest that surgical treatment surgery is associated with long-term improvement in quality of life. Ideally, a firm conclusion that the observed improvement is caused by the surgical decompression cannot be reached without including a control group that is left unoperated. This, however, poses an ethical problem; one would then have to select a subgroup of patients with the same symptom intensity and impairment as the operated patients and leave them unoperated for the follow-up time used in this study, i.e., many years.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the regional committee for medical and health research ethics (Regional - REC West) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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