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The Glasgow Benefit Inventory: a systematic review of the use and value of an otorhinolaryngological generic patient-recorded outcome measure

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Abstract

Background—The Glasgow Benefit Inventory (GBI) is a validated, generic patient-recorded outcome measure widely used in otolaryngology to report change in quality of life post-intervention.

Objectives of review—To date, no systematic review has made (i) a quality assessment of reporting of Glasgow Benefit Inventory outcomes; (ii) a comparison between Glasgow Benefit Inventory outcomes for different interventions and objectives; (iii) an evaluation of subscales in describing the area of benefit; (iv) commented on its value in clinical practice and research.

Type of review—Systematic review.

Search strategy—'Glasgow Benefit Inventory' and 'GBI' were used as keywords to search for published, unpublished and ongoing trials in PubMed, EMBASE, CINAHL and Google in addition to an ISI citation search for the original validating Glasgow Benefit Inventory paper between 1996 and January 2015.

Evaluation method—Papers were assessed for study type and quality graded by a predesigned scale, by two authors independently. Papers with sufficient quality Glasgow Benefit Inventory data were identified for statistical comparisons. Papers with <50% follow-up were excluded.

Results—A total of 118 eligible papers were identified for inclusion. A national audit paper (n = 4325) showed that the Glasgow Benefit Inventory gave a range of scores across the specialty, being greater for surgical intervention than medical intervention or 'reassurance'. Fourteen papers

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Conflict of interest
None to declare.

Supporting Information
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compared one form of surgery *versus* another form of surgery. In all but one study, there was no difference between the Glasgow Benefit Inventory scores (or of any other outcome). The most likely reason was lack of power. Two papers took an epidemiological approach and used the Glasgow Benefit Inventory scores to predict benefit. One was for tonsillectomy where duration of sore throat episodes and days with fever were identified on multivariate analysis to predict benefit albeit the precision was low. However, the traditional factor of number of episodes of sore throat was not predictive. The other was surgery for chronic rhinosinusitis where those with polyps on univariate analysis had greater benefit than those without. Forty-three papers had a response rate of >50% and gave sufficient Glasgow Benefit Inventory total and subscales for meta-analysis. For five of the 11 operation categories (vestibular schwannoma, tonsillectomy, cochlear implant, middle ear implant and stapes surgery) that were most likely to have a single clear clinical objective, score data had low-to-moderate heterogeneity. The value in the Glasgow Benefit Inventory having both positive and negative scores was shown by an overall negative score for the management of vestibular schwannoma. The other six operations gave considerable heterogeneity with rhinoplasty and septoplasty giving the greatest percentages (98% and 99%) most likely because of the considerable variations in patient selection. The data from these operations should not be used for comparative purposes. Five papers also reported the number of patients that had no or negative benefit, a potentially a more clinically useful outcome to report. Glasgow Benefit Inventory subscores for tonsillectomy were significantly different from ear surgery suggesting different areas of benefit

Conclusions—The Glasgow Benefit Inventory has been shown to differentiate the benefit between surgical and medical otolaryngology interventions as well as ‘reassurance’. Reporting benefit as percentages with negative, no and positive benefit would enable better comparisons between different interventions with varying objectives and pathology. This could also allow easier evaluation of factors that predict benefit. Meta-analysis data are now available for comparison purposes for vestibular schwannoma, tonsillectomy, cochlear implant, middle ear implant and stapes surgery. Fuller report of the Glasgow Benefit Inventory outcomes for non-surgical otolaryngology interventions is encouraged.

Patient-recorded outcome measures

Patient-recorded outcome measures are used across surgical specialties to provide quantitative measures of the impact of interventions on patients’ health-related quality of life.1–3 In otolaryngology, there is a wide range of operative procedures, many of which are elective with the primary objective to improve the quality of life. Multiple symptom or disease-specific questionnaires are used in otolaryngology practice for departmental audit and research to assess a symptom, disease or procedure, for example Sino Nasal Outcome Test (SNOT-22)4 and Voice Symptom Scale.5 However, the results of these questionnaires are not comparable across different patient groups and conditions. Given the heterogeneous nature of interventions in otolaryngology, a patient-completed questionnaire that can be used universally for all otolaryngology conditions and management options would be valuable. The EQ-5D,6 HUI-37 and SF-368 are examples of such generic questionnaires that are used routinely in assessing health-related quality of life outcome of surgeries across all specialties. There is concern that these questionnaires may not be sensitive enough to pick up health-related quality of life changes post-otolaryngology intervention.

The Glasgow Benefit Inventory

The Glasgow Benefit Inventory (GBI) is a generic patient-recorded outcome measure that was reported by Robinson et al. in 19969 and has gained widespread popularity in otolaryngology. The Glasgow Benefit Inventory is designed for use only once post-intervention, as a measure of change related to a specific surgical or medical intervention. The questionnaire, which can be completed by interview or self-completed by patients, consists of 18 questions answered using a five-point Likert scale, addressing change in health status post any intervention. The responses are then scaled and averaged to give a score with a range −100 (poorest outcome) through 0 (no change) to +100 (best outcome).10 The original validating procedures were for hearing [middle ear surgery, $n = 181$ (response rate 64%), cochlear implant, $n = 184$ (response rate 86%)], eradicating ear activity [mastoid procedures, $n = 138$ (response rate 72%)], nasal blockage and disfigurement [rhinoplasty, $n = 96$ (response rate 43%)] and pharyngeal surgery [tonsillectomy, $n = 61$ (response rate 60%)]. Principal component analysis found that questions from the Glasgow Benefit Inventory were subdivided and loaded reliably onto three distinct subscales. Twelve questions focused on general changes in health status, as well as changes in psychosocial health status were termed ‘General’. A further three questions were related to the amount of social support needed in relation to the condition being questioned (social). The remaining three questions addressed changes in physical health status including medications requirement and number of visitations to doctors required (physical). These subscales were used to elicit the profile of improvement across Glasgow Benefit Inventory scores and interventions. In order to prove a patient-recorded outcome measure is acceptable, it has to be valid, reliable and sensitive to change; for the five interventions in the original Glasgow Benefit Inventory paper, both total and subscale scores fulfilled these criteria.

While acceptability of the Glasgow Benefit Inventory is widespread in otorhinolaryngology, no review has been performed of its use. In particular, we have no knowledge on the quality of the data that are being reported. Therefore, to date, no conclusions to add to the original validating paper9 regarding the value of the Glasgow Benefit Inventory as a patient-recorded outcome measure can be reached. In addition, the original paper assessed the Glasgow Benefit Inventory measured by principal component analysis to give three subscales. However, we do not know whether these vary between interventions and their clinical objectives.

In summary, a systematic review of papers that use the Glasgow Benefit Inventory as a patient-recorded outcome measure is reported. From this, we aim to estimate the current applicability and limits of this widely used patient-recorded outcome measure.

Methodology

Search methods

‘Glasgow Benefit Inventory’ and ‘GBI’ were used to perform a search for published and unpublished and ongoing trials in PubMed, EMBASE, CINAHL and Google from the inception of the Glasgow Benefit Inventory (1996) to January 2015. In addition, a citation search from the original validating paper was used from the ISI Citation search engine.

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Selection of studies

The PRISMA flow chart Fig. 1 records the selection process. Once eligible papers ($n = 118$) had been identified, their study design was categorised. No evaluations of the quality of these papers were made apart from the percentage of study patients in whom the Glasgow Benefit Inventory was reported. An initial cut-off point for low follow-up quality was set at 50% and subsequently confirmed to be appropriate from a histogram of percentage response rate against number of papers. Ten papers that had a follow-up rate of <50% were considered to be of insufficient follow-up quality for data reporting.11–20 A further paper which included multiple conditions with $n < 10$ was also excluded.21

Data extraction and management

Two authors (JH and GGB) undertook independent assessment of the screened 118 papers using a piloted pro forma. Type of study, pathology, aim of intervention, response rate and use of other patient-recorded outcome measures were included. All data available on Glasgow Benefit Inventory reporting were recorded for total and subscale scores, including calculation of summary data from figures and raw data when results not available.

Completeness of reporting of the Glasgow Benefit Inventory data

Papers were assessed to identify those with sufficient Glasgow Benefit Inventory data for comparison purposes.

1. Sufficient: Adult cohort. Subscales reported. Distribution of individual data given.22–64
2. Low grade: Children in cohort and not reported separately. No subscales reported. Mean total score data only given.65–129

Data analysis

Given the heterogeneous nature of otolaryngology interventions, each was allocated to one of the following:

1. Interventions for hearing (bone-anchored hearing aid, cochlear implant, middle ear implant, stapes surgery).
2. Interventions for benign tumours (vestibular schwannoma).
3. Interventions for nasal function (septoplasty for nasal obstruction and endoscopic sinus surgery for chronic sinusitis).
4. Interventions for epiphora (dacryocystorhinostomy).
5. Interventions for cosmesis (rhinoplasty and auricular reconstruction/otoplasty).
6. Interventions for chronic tonsillitis (tonsillectomy).
7. Interventions for snoring.
8. Interventions for dystonia (botulinum toxin).

Data synthesis

Studies were allocated as above into subgroups based on the clinical aim of intervention. Forest plots were constructed (Excel, Microsoft Office, 2011) and Review Manager (RevMan Version 5, RevMan 5.2, Cochrane Group), with scores weighted for size of study. Heterogeneity (chi-squared) was tested for within intervention aims and subscales using RevMan 5. Heterogeneity was deemed moderate to high if total score heterogeneity was ≥30% with a significant chi-squared test. For some intervention aims (endoscopic sinus surgery and snoring surgery), meta-analysis was not relevant as only one paper was available on each. Mean total, general, social and physical subscale scores were analysed using oneway ANOVA in SPSS (IBM, version 22, SPSS v22, IBM, New York, USA) across interventions with low heterogeneity with *post hoc* Games–Howell testing used when significance across interventions was $P < 0.05$.

Results

After screening, 118 articles were assessed for eligibility (Fig. 1). A systematic review of Glasgow Benefit Inventory scores following tonsillectomy was the only quality-of-life review identified129 and included no additional studies beyond those included separately below. No reviews with new data directly relating to the Glasgow Benefit Inventory were identified.

Audit papers

One paper was a national audit of both surgical and medical outcomes including ‘reassurance’ in 4235 adult patients.66 The Glasgow Benefit Inventory scores were a secondary outcome, and only reported as means, but these did indicate that there was such a range of scores that departmental and personal audit would have to be controlled for case mix if comparisons are going to be made between departments and clinicians. All categories of surgery and medical intervention had a change in health status on the Glasgow Benefit Inventory with surgical interventions giving greater benefit compared to medical treatment or reassurance. Co-incidentally, the primary outcome of change in HUI-3 was found not to be applicable as a generic outcome measure for otolaryngology interventions as it was only with otological interventions was there a change in health status.

A further audit paper reported a department’s Glasgow Benefit Inventory outcomes following endoscopic sinus surgery without categorising what the surgery or pathology was. 118

Epidemiological papers

Two papers used the Glasgow Benefit Inventory scores to identify predictors of benefit. Koskenkorva *et al.*,44 using multifactorial analysis, found that number of days with sore throat and the number of days with fever, rather than the number of sore throats were the predictive factors that could predict quality-of-life outcomes. Even then, the precision of these factors was low. Salhab *et al.*40 found that on univariate analysis, patients with nasal polyps associated with their chronic rhinosinusitis were significantly more likely to benefit

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than those without polyp in the total and general subscales (Total 18 *versus* 5, $P = 0.045$, General 25 *versus* 8, $P = 0.02$).

Validating case series

Six studies attempted to validate the Glasgow Benefit Inventory against another patient-recorded outcome measure.34,35,46,54,121,127 Five of these compared with another patient-recorded outcome measure35,46,54,121,127 (Fairley Nasal Questionnaire (FNQ), Blepharospasm Disability Index (BDSI), HUI 3, OMDQ 25). In only one paper was there an attempt to compare the Glasgow Benefit Inventory with a patient-recorded outcome measure Hearing Disability and Handicap Scale (HDHS) and objective testing of hearing outcomes. 34 There was no significant correlation between HDHS and hearing or Glasgow Benefit Inventory and hearing.

Comparative papers

Fourteen papers11,36,37,47–49,53,64,83,88,92,95,98,119 compared one type of surgery against another type of surgery for the same condition. In none was a power analysis reported of the numbers required having each operation to show a difference. Only one of these papers36 was a single-blind randomised trial. In 13 of the 14 case series, there was no difference in the Glasgow Benefit Inventory scores between operations nor in any other outcome. The number of patients in these case series was ~30–40 for each operation and thus almost certainly underpowered. Myrseth *et al.*49 found better outcomes in gamma knife radio surgery *versus* microsurgery at 2 years in total (3.2 *versus* −10.7), general (−0.3 *versus* −17.2) and physical (5.3 *versus* −10.0) scales.

Case series

A total of 94 papers reported uncontrolled case series of an operation, the majority of these being otological. All intervention aims had a mean positive total Glasgow Benefit Inventory ranging between 16.5 and 43.9, except for intervention for benign tumour (vestibular schwannoma), which had an overall negative score of −4.8. There were significant differences across the range of interventions (low heterogeneity) in total, general, social and physical support subscales (ANOVA $F = 103.5$-$P < 0.001$, $F = 68.2$-$P < 0.001$, $F = 4.2$-P 0.02, and $F = 46.2$-$P < 0.001$.)

Data analysis

All the above papers, bar the two audit papers,66,118 had Glasgow Benefit Inventory data of a specific operation that could be used for comparison purposes and data synthesis. Initial analysis of the quality criterion of at least a 50% response rate to indicate studies of quality showed that this was a valid cut-off point. Using this criterion, 43 of the 118 (36%) papers had sufficient quality of Glasgow Benefit Inventory data and a follow-up rate of at least 50% to be included in quantitative analysis. All papers reported a surgical intervention, and these were grouped into 12 categories of the aims of surgery.

The characteristics of these papers are grouped according to the predicted aim of the intervention in Table 1. The heterogeneity between intervention scores is detailed in Table 2. Where heterogeneity was deemed to be moderate to high (>30% in total and or subscale,

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with significant chisquared test), it was considered these were too great for the combined data to be reported. This applied to septoplasty, rhinoplasty, otoplasty, dacryocystorhinostomy and botulinum therapy with septoplasty and rhinoplasty giving the greatest heterogeneity (98% and 99%). The most likely reasons for this are the heterogeneity of the pathology and multiple surgical objectives.

For cochlear implant, middle ear implant, stapes surgery, vestibular schwannoma interventions and tonsillectomy, there was minimal-to-nil heterogeneity and scores are representative of intervention (Fig. 2 and Table 3). It is of note that the objective/s of these interventions are narrower than the other interventions. An attempt was made to narrow the objectives of bone-anchored hearing aid taking out the paper by Faber *et al.*27 which reported its use for single-sided deafness but this did not lessen the heterogeneity.

Where papers did not fit into easily defined categories or intervention or pathology, it was felt that combining these would only add heterogeneity. Therefore, these eight papers are reported in Table S1 and will not be further analysed.55,57–60,62,63,71

Comparative intervention analysis

Between interventions for vestibular schwannoma (microsurgery $n = 159$, gamma knife radiosurgery $n = 154$, radiotherapy $n = 42$, and $n = 36$ observation), there was no significant difference in total score ($F = 1.8$, $P = 0.26$), general ($F = 4.75$, $P = 0.06$), physical ($F = 0.96$, $P = 0.48$) and social support score ($F = 3.8$, $P = 0.09$). The total numbers for each of the interventions clinically support this finding of no difference. Overall, there are negative scores for total, general and physical subscales reflecting worsening of quality of life for this pathology across the range of interventions (Fig. 3).

Percentage benefit

Five papers reported, as well as the mean Glasgow Benefit Inventory data, the percentage of patients that had no or negative benefit. Three of these were for management of vestibular schwannoma48,49,51 which mirrored the negative mean Glasgow Benefit Inventory totals score [−4.8 (−9.4, 32.8)] of all the different management strategies for that condition.

Martin *et al.*87 describe a case series of 54 patients given a bone-anchored hearing aid for single-sided deafness, five were non-users because of negative benefit, a further three continued usage despite reporting negative benefit and six continued to use but without any benefit. So overall, 14 of 54 (30%) patients had no or negative benefit with a bone-anchored hearing aid for single-sided deafness.

Kyrodimos *et al.*76 reported 30 patients following intratympanic gentamicin for Meniere's disease and nine patients (50%) expressed an overall Glasgow Benefit Inventory benefit, while 6 (33%) expressed no benefit and three patients (17%) complained of a negative effect of the intervention.

An additional paper by Koskenkorva *et al.*44 reported negative Glasgow Benefit Inventory benefit score of – 20 in one of 142 tonsillectomy patients, and from their distribution graphs,

a further five patients had no benefit giving an overall no or negative benefit rate for tonsillectomy of 4%.

Discussion

Summary of findings

The Glasgow Benefit Inventory has been popularised since its design and used as a generic patient-recorded outcome measure in over 100 surgical studies for otorhinolaryngological conditions.

Fourteen papers compared one surgical intervention against another procedure for a specific condition but in only one paper on surgery for vestibular schwannoma was it possible to show a statistically significant difference in the Glasgow Benefit Inventory scores at 2 years follow with greater benefit from gamma knife radiosurgery *versus* conventional micro-surgery. Interestingly, none of the other outcomes in these 14 papers was able to show a difference in greater than one of the subscales.

Two studies used the total Glasgow Benefit Inventory scores to identify factors to predict benefit, one of the most clinically useful aspects of having a patient-recorded outcome measure outcome as the predictive factor.

A quantitative analysis of Glasgow Benefit Inventory scores from surgery for ear, nose and throat conditions with 12 different aims of intervention is reported after characterising the study design and grading the quality of the evidence for completeness of follow-up. Where several case series were of the same surgical procedure, forest plots were performed of the Glasgow Benefit Inventory total and principal component subscores to better define the confidence intervals. The heterogeneity between such case series varied considerably between 0% and 99%. However, it was evident that where the surgery could only be for a very specific aim, such as cochlear implantation and tonsillectomy, then the heterogeneity was sufficiently acceptable to give meta-analysis data of value for audit purposes.

One advantage of the Glasgow Benefit Inventory is that it has both positive and negative scores. This was evident in the management of patients with vestibular schwannoma where the overall total Glasgow Benefit Inventory score was –5.1 (–13.1, 3.0), and there being no difference between observation and the three categories of active intervention. Our recommendation is that the percentages of patients that benefitted, had no benefit or were worse after a procedure be routinely reported. Such Glasgow Benefit Inventory data could be more clinically useful than the current mean and standard deviation data being the method most commonly used. To date, such data are only available from five case series.

The analysis of case series data showed material heterogeneity for most surgical procedures and the large Scottish National audit of otorhinolaryngological practice likewise had a wide range of mean Glasgow Benefit Inventory scores from reassurance to surgery. As such, departmental audit or individual audit of surgical practices should not have Glasgow Benefit Inventory as the main clinical outcome unless controlled for the case mix.

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Review strengths

As a systematic review, quality of reporting of the Glasgow Benefit Inventory scores from the literature identified was used with a cut-off of >50% of loss to follow-up being used and justified by the distribution analysis. From eligible papers, the Glasgow Benefit Inventory data reported varied in extent but where it could be used, such as in the comparison between the scores between aims of intervention, it was included. Apart from identifying large numbers of surgical case series reporting the Glasgow Benefit Inventory scores, one paper demonstrated its use to identify factors predicting benefit.44

Review limitations

The majority of the literature reports surgical series. The majority of patients referred to otorhinolaryngological clinics are not managed surgically. Even those managed surgically could be managed otherwise. So the Glasgow Benefit Inventory scores of patients managed non-surgically are important to have comparisons with. As much Glasgow Benefit Inventory data were included in the analysis as possible but many papers had to be excluded because the results were displayed graphically from which numerical data could not be assessed. It was not considered viable to request further data from study authors as the majority were written by trainees' in non-research establishments. What was searched for and not identified except in five papers48,51,76,87,98 were reports of the percentage of patients for whom there was no or negative benefit of surgery. This could be one of the main strengths of the Glasgow Benefit Inventory scoring system that must be further investigated as it is with such percentages that differences between interventions or their aims could become more obvious.

Implications for clinical practice and research

This review has highlighted the absence of any recommended method of reporting Glasgow Benefit Inventory data. This has stimulated the creation of a MRCHI website10 which will be regularly updated. The 118 papers identified reporting Glasgow Benefit Inventory outcomes, in retrospect, have all weaknesses in method of reporting the data. The Glasgow Benefit Inventory was specifically designed to have both positive and negative outcomes with the aim of being able to say that following an intervention x% of patients benefited, y% of patients did not benefit and z% of patients were worse. Such data could be used to inform patients of what the likelihood of overall benefit would be in addition to how successful technically the intervention was. It would also allow the Glasgow Benefit Inventory to be used for individual and departmental audit. What is not known is the range around a zero Glasgow Benefit Inventory score that would define no positive or negative benefit. Till this has been defined, what can be done is to report Glasgow Benefit Inventory outcomes as distribution plots. Arbitrary cut-off points within a given case series might then become obvious.

At this stage, it probably would be incorrect to compare the benefit of interventions that did not have the same clinical objective such as surgery for hearing *versus* surgery for recurrent sore throats. This is because the components making up the total Glasgow Benefit Inventory score are not the same. This aspect needs further investigation using up-to-date statistical methods for factor rather than principal component analysis.

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We have provided a standardised set of representative outcome scores including distribution of data on five otolaryngology interventions, with principal component subscales. As with all representative scores, these are an average of all patients and surgeons, and therefore, it is expected these represent a random selection of patients with good and poor outcomes, as well as surgeons with better and worse outcomes. Thus, the data from these highly selective series are unlikely to give the same Glasgow Benefit Inventory benefits when applied to overall otorhinolaryngolical practices.66

Case series are required of interventions yet to be reported, or reported insufficiently to give usable data. This should include patients managed non-surgically, with medication, physical therapy or the supply of devices and include the above-suggested distribution plots of the data. Such data would also be of interest to ascertain the area of benefit using subscore analysis or indeed performing principal component analysis. In addition, especially if prospectively planned, such case series can on multifactorial analysis give predictions of patient benefit.

Factor analysis is merited of tonsillectomy patients' responses in comparison with other surgical and non-surgical interventions to identify variations that could lead to reconsideration renaming or reconfiguration of the subscores.

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Keypoints

- Glasgow Benefit Inventory is a validated patient-recorded outcome measure to assess quality of life post-medical and surgical interventions in otolaryngology albeit to date no medical interventions have been reported in detail.
- In case series, it can be used to identify predictors of benefit.
- Subscores can be useful in characterising the areas of benefit when a comparison is being made between different interventions where the surgical objectives might seem similar.
- Although applicable for all otorhinolaryngological patients, there is sufficient differences in the mean benefit between six of the 11 surgical interventions for comparisons to be made between departments or individual clinicians presumably because of the greatly varying indications.
- For cochlear implant, middle ear implant, stapes surgery, tonsillectomy and management of vestibular schwannoma, there is consistency of data in meta-analysis to suggest that these interventions can be compared for audit purposes.
- Higher quality of reporting of the Glasgow Benefit Inventory data and investigation of non-surgical interventions are desirable reporting the distribution of the data to allow percentages that had no or negative benefit to be reported.

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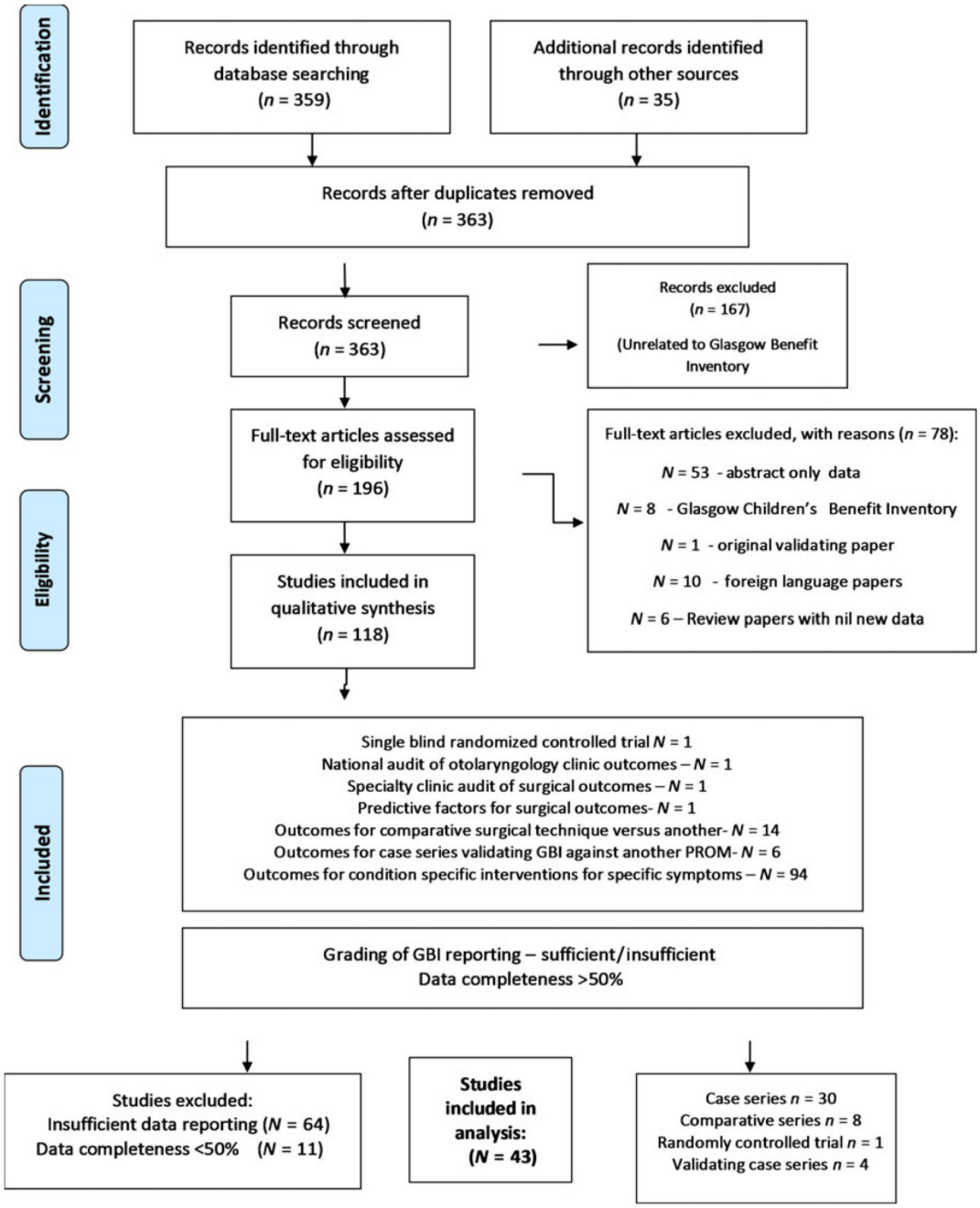

Fig. 1.
PRISMA Statement of search strategy and inclusion and exclusion criteria.

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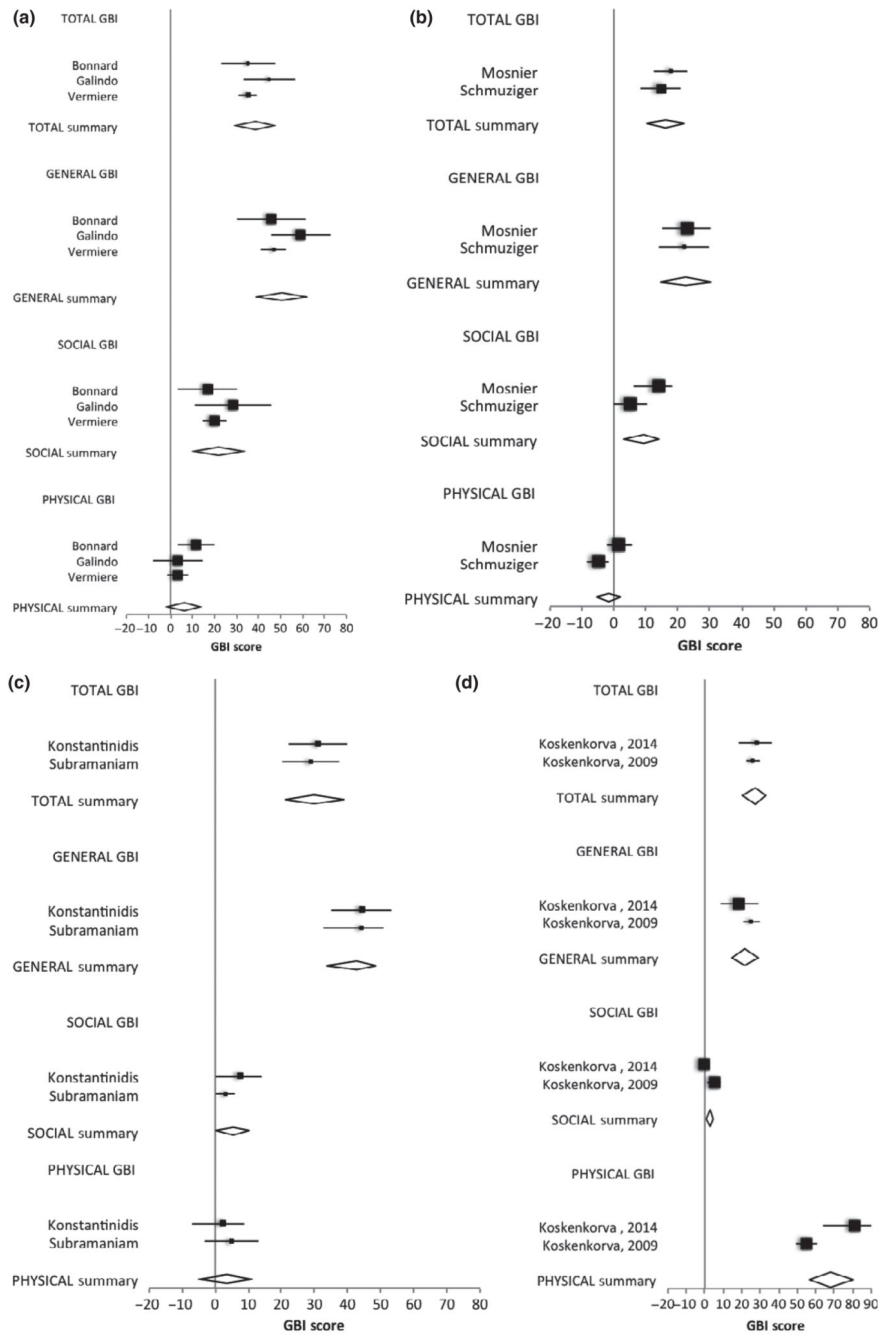

Fig. 2.

Interventions for hearing (a–c): cochlear implant, middle ear implant (MEI) and stapes surgery. Intervention for tonsils (d). Forest plot of intervention for hearing and tonsils data with low heterogeneity: boxes represent mean score with lines for 95% confidence intervals. Summary (diamond) shows mean score with 95% confidence interval.

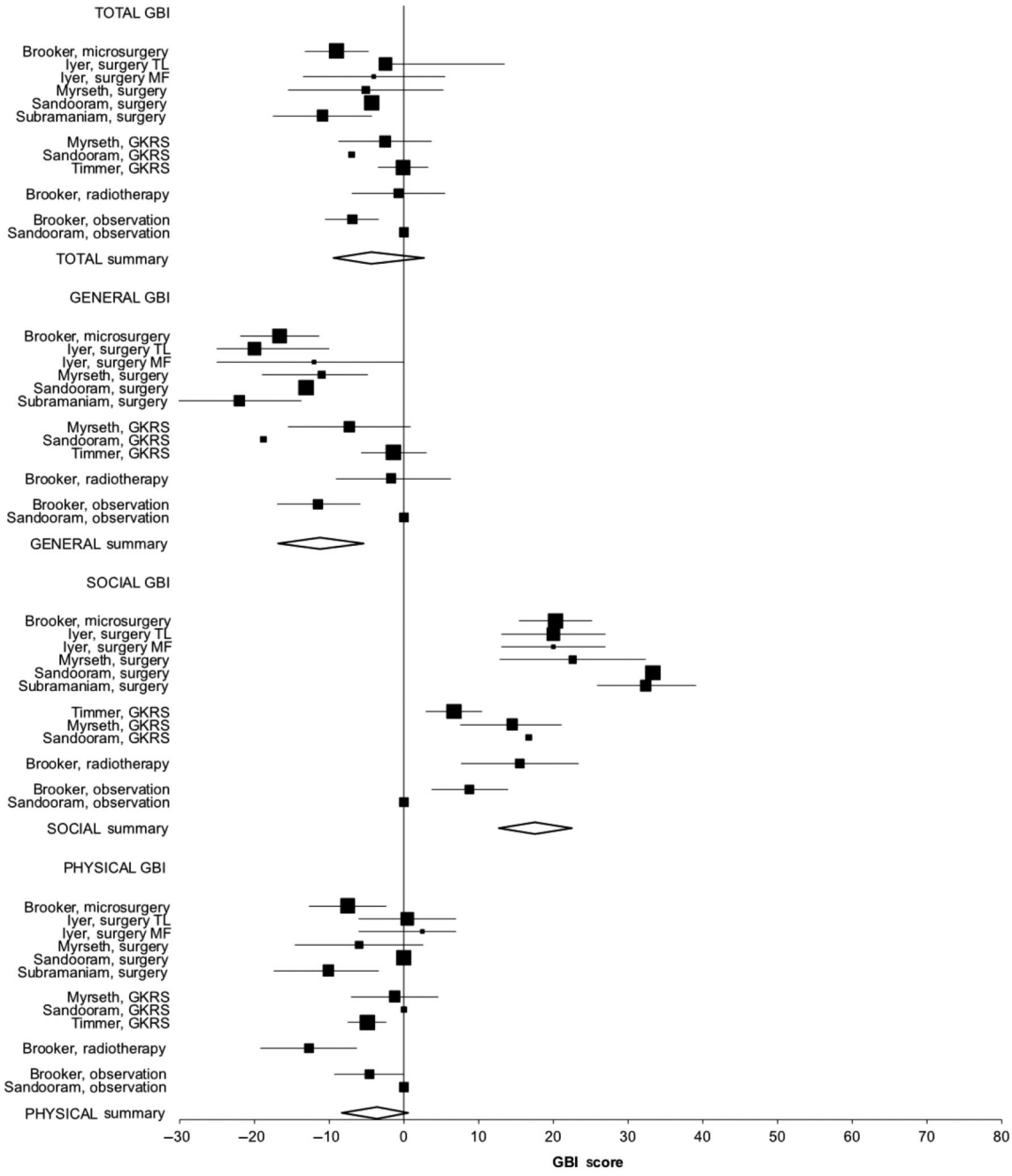

Fig. 3.

Intervention for vestibular schwannoma: boxes represent mean score with lines for 95% confidence intervals. Summary (diamond) shows mean score with 95% confidence interval. Five studies were included in analysis for quality of life post-intervention for vestibular schwannoma (VS). Iyer *et al.*48 reported a comparative series of outcome following surgery via the translabyrinthine (TL) approach *versus* middle fossa (MF) approach. Subramaniam *et al.*50 and Timmer *et al.*51 described a case series on outcomes following microsurgery and gamma knife radio surgery (GKRS), respectively. Brooker *et al.*47 report a three-arm

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comparative series of microsurgery, radiation and observation. Myrseth *et al.*49 undertook a comparative series of surgery *versus* GKRS.

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Table 1

Included papers with adequate quality Glasgow Benefit Inventory reporting by intervention ($N = 39$)

Paper	Question	Paper type	Response number (%)	Reporting	Reporting of other scores
Bone-anchored hearing aid					
Arunachalam *et al.*22	Bone-anchored hearing aid as a unilateral hearing aid	Case series	51 (85)	Mean, Cochlear implant of total and subscales	Nil
De Wolf *et al.*23	Bone-anchored hearing aid in older hearing aid users, as a conventional unilateral hearing aid	Case series	134 (80)	Mean and SD for total and subscales, derived cochlear implant	PTA APHAB NCIQ HHIE S
Faber *et al.*27	Bone-anchored hearing aid in the elderly with single sided deafness	Case series	11 (100)	Mean and SD for total and subscales, derived cochlear implant	APHAB CROS HHIE-S
Gillet *et al.*24	Bone-anchored hearing aid as a conventional hearing aid	Case series	41 (60)	Individual score data. Mean, cochlear implant derived for total and subscales	Nil
Ho *et al.*25	Bone-anchored hearing aid, effect of bilateral aid	Case series	71 (76)	Mean, cochlear implant, Range for total and subscales	PTA HINT
Ricci *et al.*26	Bone-anchored hearing aid: children and adults for unilateral disease	Case series	16 adults (96)	Individual score data. Mean, cochlear implant derived for total and subscales	PTA
Wilkie *et al.*61	Bone-anchored hearing aid: Osseointegrated hearing implant surgery	Case series	30 (100)	Mean with cochlear implant for total and subscale data	
Cochlear implant					
Bonnard *et al.*28	Cochlear implant: bilateral cochlear implants and digisonic binaural cochlear implant	Case series	13 (87)	Mean with SD for total and subscales, derived cochlear implant	Speech perception and localization, APHAB
Galindo *et al.*29	Fine structure processing improves telephone speech perception in cochlear implant users	Case series for Glasgow Benefit Inventory data	19 (50)	Mean with SD for total and subscales,	Fabers questionnaire Free-field audiometry

Paper	Question	Paper type	Response number (%)	Reporting	Reporting of other scores
				derived cochlear implant	
Vermeire *et al.*30	Cochlear implant: Benefit in the elderly, post-lingually deafened	Case series	81 (91)	Mean with SD for total and subscales, cochlear implant derived	HHIA
Middle ear implant					
Mosnier *et al.*31	Benefit of VSB in patients implanted for 5–8 years	Case series	62 (81)	Mean with SEM, cochlear implant derived for total and subscales	PTA
Schmuziger *et al.*32	Long-term outcome of VSB	Case series	20 (83)	Mean with cochlear implant for total and subscales	PTA
Stapes surgery					
Konstantinidis *et al.*33	Causse laser stapedotomy	Case series	34 (76)	Mean with cochlear implant for total and subscales	Air bone gap
Subramaniam *et al.*34	Hearing outcomes after stapes surgery	Validating case series	21 (65)	Mean, SD for total and subscales, derived cochlear implant	HDHS PTA
Septoplasty					
Akduman *et al.*64	Surgical management of nasal obstruction	Case series	134 (100)	Septoplasty only group – Mean and SD for total and subscales, derived cochlear implant	NOSE
Konstantinidis *et al.*35	Outcomes of nasal septal surgery	Validating case series	26 (76)	Above criterion results – Mean, median, range and SD for total and subscales, cochlear implant derived	FNQ
Uppal *et al.*46	Nasal septal surgery for obstruction	Validating case series	62 (75)	Mean with SD for total and subscales, cochlear	NSS

Paper	Question	Paper type	Response number (%)	Reporting	Reporting of other scores
				implant derived	
Dacryocystorhinostomy					
Hii *et al.*37	Dacryocystorhinostomy: External *versus* endonasal	Comparative series	68 (86)	Mean with cochlear implant, for total and subscales	Nil
Spielmann *et al.*38	Dacryocystorhinostomy: Endonasal	Case series	92 (71)	Mean and cochlear implant for total and subscales	Nil
Yeniad *et al.*39	Dacryocystorhinostomy: transcanalicular bilateral Dacryocystorhinostomy with a diode laser	Case series	38 (100)	Mean with cochlear implant for total and subscales	Nil
Endoscopic sinus surgery					
Salhab *et al.*40	ESS: polyposis *versus* sinusitis	Comparative series	77 (63)	Median and IQR for total and subscales	Nil
Rhinoplasty					
Chauhan *et al.*41	Adolescent rhinoplasty	Case series	30 (100)	Mean with SD and cochlear implant for total and subscales	Nil
Draper *et al.*42	Rhinoplasty	Case series	51 (65)	Mean with SD and cochlear implant for total and subscales	Nil
Otoplasty					
Braun *et al.*52	Otoplasty using suture techniques	Case series	21, adults (74)	Mean, median, SD and cochlear implant for total and subscales	Nil
Braun *et al.*43	Auricular reconstruction	Case series	45, adults (83)	Mean, median, SD, for total and subscales, cochlear implant derived	Nil
Tonsillectomy					
Koskenkorva *et al.*44	Tonsillectomy: predictive factors for QOL improvement	Case series	142 (93)	Median total and subscales with confidence intervals derived	Nil

Paper	Question	Paper type	Response number (%)	Reporting	Reporting of other scores
				from graphs	
Koskenkorva *et al.*45	Tonsillectomy: QOL in adults	Case series	62 (89)	Mean and SD for total and subscales, cochlear implant derived	Nil
Snoring surgery					
Uppal *et al.*36	Laser palatoplasty *versus* uvulectomy with punctate palatal diathermy	RCT, single blind	62 (75)	Mean, SD, SEM for total and subscales, cochlear implant derived	Snoring score
Vestibular schwannoma					
Brooker *et al.*47	Vestibular schwannoma: microsurgery, radiation or observation	Comparative series	229 (66)	Mean, SD and better/worse for totals and subscales, cochlear implant derived	SF-12
Iyer *et al.*48	Hearing preservation effects post vestibular schwannoma surgery	Comparative series	83 (80)	Mean, and cochlear implant for total and subscales	SF-36
Myrseth *et al.*49	Vestibular schwannoma: surgery or GKRS	Comparative series	80 (87)	Mean, SD, range for total and subscales, cochlear implant derived	SF36 Tinnitus and vertigo VAS
Subramaniam *et al.*50	Unilateral profound hearing loss and CPA surgery	Case series	51 (93)	Mean and cochlear implant for total and subscales	Hearing outcomes
Timmer *et al.*51	Vestibular schwannoma: GKRS	Case series	97 (91)	Mean, SD, range for total and subscale cochlear implant derived	SF 36 Audio-vestibular symptoms
Botulinum toxin					
Bhattacharyya *et al.*53	Botulinum toxin for spasmodic dysphonia and OMD	Comparative series	23 (74)	Mean with cochlear implant for total and subscales	Nil
Merz *et al.*54	Botulinum for OMD	Validating case series	25 (83)	Mean with SD for total and subscales, cochlear implant derived	OMD-25

Paper	Question	Paper type	Response number (%)	Reporting	Reporting of other scores
Miscellaneous					
MacAndie *et al.*55	Botulinum for essential blepharospasm	Case series	36 (82)	Mean and cochlear implant for total and subscales	Nil
Banerjee *et al.*56	Intratympanic gentamicin for Meniere's	Case series	17 (81)	Mean and cochlear implant for total and subscales	Nil
Potter *et al.*57	Canalplasty for chronic OE	Case series	13 (93)	Mean and cochlear implant for total and subscales	PTA
Leong *et al.*58	Endoscopic stapling of Zenker's diverticulum	Case series	32 (74)	Mean, SD and cochlear implant for total and subscales	Nil
Hempel *et al.*59	Outer ear canal surgery for exostoses	Case series	39 (77)	Mean, SD, Range and cochlear implant for total and subscales	Nil
Hill *et al.*60	Collagen vocal cord augmentation for Hypophonia in Parkinson's' patients	Case series	12 (71)	Mean, SD and cochlear implant for total and subscales	Nil
Mahroo *et al.*62	Outcomes of ptosis surgery over time	Case series	50 (79)	Mean and SD for total and subscales with cochlear implant derived	Nil
Crosbie *et al.*63	Meatoplasty and tympanoplasty for chronic OE	Case series	16 (84)	Mean, SD and cochlear implant for total and subscales	Nil

PTA, Pure tone audiogram; APHAB, Abbreviated profile of hearing aid benefit; NCIQ, Nijmegen cochlear implantation questionnaire; HHIE S, Hearing handicap inventory for the elderly [screening version]; CROS, Contralateral routing of signal; HINT, Hearing in noise testing; HHIA, Hearing handicap inventory; NOSE, Nasal obstruction and septoplasty effectiveness; QOL, Quality of life; GKRS, Gamma Knife Radiosurgery; CPA, Cerebellopontine angle; OMD, Oromandibular dystonia; OE, Otitis externa.

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Table 2

Heterogeneity across interventions by score, measured by inconsistency (I^2) and chi-squared testing. Interventions with asterisk were deemed to have moderate-to-significant heterogeneity

Intervention	Total score heterogeneity (I^2) (P-value χ^2)	General score heterogeneity (I^2) (P-value χ^2)	Social score heterogeneity (I^2) (P-value χ^2)	Physical score heterogeneity (I^2) (P-value χ^2)	Moderate-to-significant heterogeneity
Bone-anchored hearing aid	57% (0.02)	62% (0.01)	35% (0.12)	70% (0.01)	*
Cochlear implant	9% (0.33)	26% (0.26)	0% (0.54)	36% (0.21)	
ME	0% (0.45)	0% (0.89)	65% (0.07)	69% (0.07)	
Stapes	0% (0.71)	0% (0.99)	14% (0.28)	0% (0.65)	
Vestibular schwanoma	38% (0.12)	55% (0.09)	69% (0.01)	34% (0.14)	
Tonsils	0% (0.69)	34% (0.22)	N/A	40% (0.20)	
Septal	99% (<0.01)	67% (0.01)	99% (<0.01)	91% (0.01)	*
Dacryocystorhinostomy	76% (0.01)	84% (<0.01)	70% (0.02)	82% (<0.01)	*
Rhinoplasty	98% (<0.01)	99% (<0.01)	94% (<0.01)	54% (0.14)	*
Otoplasty	60% (0.09)	64% (0.09)	0% (0.77)	65% (0.09)	*
Botulinum	70% (0.04)	79% (0.01)	85% (0.01)	65% (0.06)	*

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Table 3

Mean outcome scores of included quantitative analysis studies for interventions with low heterogeneity, $N = 19$, $n = 816$

Paper type Number of studies, *N* Number of patients, *n*	Glasgow Benefit Inventory Total Mean (95% CI)	Glasgow Benefit Inventory General Mean (95% CI)	Glasgow Benefit Inventory Social support Mean (95% CI)	Glasgow Benefit Inventory Physical Mean (95% CI)
Cochlear implant $N = 3$, $n = 113$	38.4 (29.0, 47.9)	50.7 (38.9, 62.1)	20.1 (9.8, 33.8)	5.0 (−2.2, 14.2)
ME $N = 2$, $n = 100$	16.3 (10.4, 22.1)	22.5 (14.7, 30.2)	9.6 (−3.1, 14.2)	−2 (−5.47, 2.1)
Stapes $N = 2$, $n = 55$	29.9 (21.0, 38.7)	42.7 (33.8, 48.6)	5.3 (0.2, 10.0)	3.5 (−5.2, 11.0)
Vestibular schwanoma $N = 5$, $n = 482$	−4.8 (−9.4, 2.7)	−11.2 (− 17.2, −5.9)	17.6 (12.7, 22.5)	−3.6 (−8.3, 0.6)
Tonsils $N = 2$, $n = 66$	27 (20.3, 32.8)	21.5 (14.5, 29.2)	2.5 (0.8, 4.2)	68 (46.9, 80)
Comparison across interventions	$F = 103.5$, $P < 0.001$	$F = 68.2$, $P < 0.001$	$F = 4.2$, $P = 0.02$	$F = 46.2$, $P < 0.001$