The Canadian Journal of Neurological Sciences (2024), 1–20
doi:10.1017/cjn.2024.273

Canadian Journal of Neurological Sciences
Journal Canadien des Sciences Neurologiques

Original Article

Quality of Life Factors and Measurement in Adult Meningioma Patients: A Systematic Review

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ABSTRACT: ***Background:*** Meningiomas are common brain neoplasms that can significantly influence health-related quality of life (HRQOL), yet the factors influencing HRQOL in adult patients remain unclear. We aimed to bridge this knowledge gap by determining these key factors. ***Methods:*** We conducted a systematic review, searching EMBASE, MEDLINE, CINAHL, Scopus and PsycINFO up to February 2024. We included original, peer-reviewed studies focusing on adult patients (>18 years) with current or past meningioma at any stage of treatment that measured HRQOL or its proxies in relation to patient-, tumour- and treatment-related factors. Two independent reviewers screened abstracts and full-texts, selecting studies with an acceptable risk of bias for data extraction and narrative synthesis. The protocol of this review was registered on PROSPERO (# CRD42023431097). ***Results:*** Of $N = 3002$ studies identified, $N = 31$ studies were included. Key factors found to influence HRQOL in adult meningioma patients include surgery, radiotherapy, neurological function, functional status, comorbidities, sleep quality, psychological impairment, age and employment. Factors related to tumour characteristics yielded inconsistent findings. Heterogeneity and inconsistencies in HRQOL measurement across studies hindered definitive conclusions about the impact of factors on HRQOL. ***Conclusion:*** Our review elucidates the multifaceted influences on HRQOL in meningioma patients, with significant variability due to patient-, tumour- and treatment-related factors. We emphasize the need for standardized, disease-specific HRQOL assessments in meningioma patients. Collaborative efforts towards consistent, large-scale, prospective research are essential to comprehensively understand and improve HRQOL, thereby enhancing tailored care for this population.

RÉSUMÉ : Facteurs et mesures de la qualité de vie chez des patients adultes atteints de méningiome : une analyse systématique. ***Contexte :*** Les méningiomes sont des néoplasmes cérébraux courants qui peuvent influencer de manière notable la qualité de vie liée à la santé (QVLS). Toutefois, les facteurs influençant la QVLS chez les patients adultes restent peu clairs. Nous avons ainsi cherché à combler ce manque de connaissances en déterminant ces facteurs clés. ***Méthodes :*** Nous avons procédé à un examen systématique au moyen de recherches dans Embase, MEDLINE, CINAHL, Scopus et PsycINFO, et ce, jusqu'en février 2024. À cet effet, nous avons inclus des études originales, évaluées par des pairs, portant sur des patients adultes (>18 ans) atteints ou ayant été atteints d'un méningiome, quel que soit le stade du traitement, et mesurant la QVLS ou ses variables indirectes en relation avec des facteurs liés au patient, à la tumeur et au traitement. Deux examinateurs indépendants ont passé au crible les résumés et les textes complets, sélectionnant les études présentant un risque de biais acceptable pour l'extraction des données et la synthèse narrative. Le protocole de cette analyse a été enregistré sur PROSPERO (# CRD42023431097). ***Résultats :*** Sur les 3002 études identifiées, 31 ont été retenues. Les principaux facteurs qui influencent la QVLS chez les adultes atteints de méningiome sont la chirurgie, la radiothérapie, la fonction neurologique, l'état fonctionnel, les comorbidités, la qualité du sommeil, les troubles psychologiques, l'âge et l'emploi. À noter que les facteurs liés aux caractéristiques de la tumeur ont donné à voir des résultats contradictoires. L'hétérogénéité et les incohérences dans la mesure de la QVLS d'une étude à l'autre nous ont en fin de compte empêché de tirer des conclusions définitives quant à l'impact de ces facteurs sur la QVLS. ***Conclusion :*** Notre étude a permis d'élucider les influences multiples de la QVLS de patients atteints de méningiome, avec une variabilité importante attribuable à des facteurs liés au patient, à la tumeur et au traitement. Nous voulons souligner la nécessité d'évaluations normalisées et spécifiques de la QVLS chez des patients atteints de méningiome. Des efforts de collaboration en vue d'une recherche prospective cohérente et à grande échelle sont essentiels pour comprendre et améliorer la QVLS de manière globale et ainsi améliorer les soins adaptés à cette population.

Keywords: brain neoplasms; brain tumours; health-related quality of life; meningeal neoplasms; meningiomas; neuro-oncology; neurosurgery; patient-reported outcomes; psychological well-being; quality of life

(Received 12 February 2024; final revisions submitted 30 April 2024; date of acceptance 20 May 2024)

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Cite this article: Jonas K, Fazari M, Cusimano MD, and Ahn M. Quality of Life Factors and Measurement in Adult Meningioma Patients: A Systematic Review. *The Canadian Journal of Neurological Sciences*, https://doi.org/10.1017/cjn.2024.273

Introduction

Meningiomas represent approximately 30% of all primary brain neoplasms[1,2] and can have a substantial impact on the health-related quality of life (HRQOL) of patients before and after treatment.[3–7] Recently, there has been an increased focus on the effect of meningiomas on HRQOL. Considering the generally favourable survival rates after treatment, understanding the factors affecting HRQOL is crucial for tailoring patient care.

Previous work in this field is limited, with prior reviews primarily focusing on clinical outcomes, such as overall survival, recurrence rates or neurocognitive impairment.[3–5] A predominant portion of earlier reviews investigated HRQOL broadly in patients with a variety of brain tumours or only in relation to a handful of specific factors.[3,6–9] Our review is novel with its focus on identifying a comprehensive array of factors that may affect HRQOL in patients with meningioma.

Methods

Eligibility criteria

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used to report results, and the PICO (Participants, Interventions, Comparators and Outcomes) framework was used to select studies for inclusion.[10] The inclusion criteria were (1) adults 18 years of age or older; (2) currently diagnosed with meningioma or have undergone treatment for meningioma; (3) average follow-up time is less than 10 years; (4) patients at any treatment stage, to fully assess HRQOL impacts across the disease spectrum; (5) research examining clinical, treatment, psychological, sociodemographic factors, disease-specific symptoms and patient satisfaction with treatment as associated with HRQOL; (6) studies comparing patients with and without treatment, with and without meningioma, or HRQOL assessments before and after treatment, as well as those without any comparison group; and (7) studies that explicitly measured HRQOL or a proxy using questionnaires administered to patients or caregivers or providers on their behalf. Regarding treatment as a factor (e.g. surgery, radiotherapy), studies had to either compare meningioma patients with and without treatment or compare HRQOL measurements before and after treatment.

Exclusion criteria were (1) studies involving paediatric populations, as meningiomas typically affect middle-aged or older adults; (2) studies where the age criterion was unspecified, unless the mean and lower age limit were above 18; (3) studies focused on rare, treatment-related complications or complementary/alternative treatments; (4) sources of grey literature such as editorials, expert opinion and policy documents, unless containing references to peer-reviewed research; and (5) studies published in a language other than English due to limited resources and capacity for language translation. There were no restrictions imposed on geographic location, setting or publication year. Eligible study designs were cross-sectional, longitudinal, observational, experimental, quasi-experimental, case series and case reports, with a requirement for originality and peer-reviewed publication.

Search strategy

An academic librarian provided search strategy guidance on five electronic databases: Ovid EMBASE, Ovid MEDLINE, EBSCO CINAHL, Scopus and Ovid PsycINFO. Details of the strategy and keywords for MEDLINE, which were adapted for each database, are found in Supplementary Appendix I. Reference lists of included studies and relevant reviews were examined to identify further studies for inclusion through snowballing methods. We received biweekly email updates from MEDLINE based on the search strategy up to February 2024 to ensure the review was up to date.

Study selection

Search results were uploaded to Covidence. Titles and abstracts of studies were screened using PICO and exclusion criteria by two independent reviewers (MF and KJ). As a measure of interrater reliability, an average Cohen's kappa statistic of 0.9 was achieved before proceeding to the full-text stage, which indicated near-perfect agreement between reviewers. Relevant abstracts underwent an independent full-text review for inclusion by the same two independent reviewers using the same eligibility criteria.

Critical appraisal

The methodological quality of each included article from the full-text screen was assessed by two independent reviewers (KJ and MA) using a Joanna Briggs Institute (JBI) critical appraisal tool specific to the study type or design.[11] Studies demonstrating significant flaws or a high risk of bias received a poor assessment and were thus excluded.

Data extraction

Data was extracted from included studies and stored in an Excel spreadsheet. Title, authors, year of publication, study design, study setting, PICO, participant demographics, duration of follow-up, HRQOL tool(s) used, key findings relevant to the research question, strengths/limitations and disclosures were extracted from each included study. Authors of studies with missing data were contacted up to two times over email to request additional information where required.

Data synthesis and analysis

Extracted data were synthesized and organized by theme to reflect the main HRQOL factors investigated by the included studies. A meta-analysis was deemed infeasible due to heterogeneity in multiple areas across the studies, including the measurement of HRQOL factors, analytic approaches employed and outcome reporting modalities, which would compromise the validity of any pooled effect size calculations.[12,13] Results were reported in accordance with the BMJ Synthesis Without Meta-Analysis (SWiM) Reporting Guidelines.[14] We present a narrative synthesis highlighting the key factors potentially influencing HRQOL in meningioma patients, with consideration of the strengths and limitations of the evidence and any potential biases.

The protocol for this systematic review was registered on the International Prospective Register of Systematic Reviews, PROSPERO, and is available online: https://www.crd.york.ac.uk/prospero/. The registration number is CRD42023431097.

Ethics approval

Institutional Research Ethics Board approval was not required.

https://doi.org/10.1017/cjn.2024.273

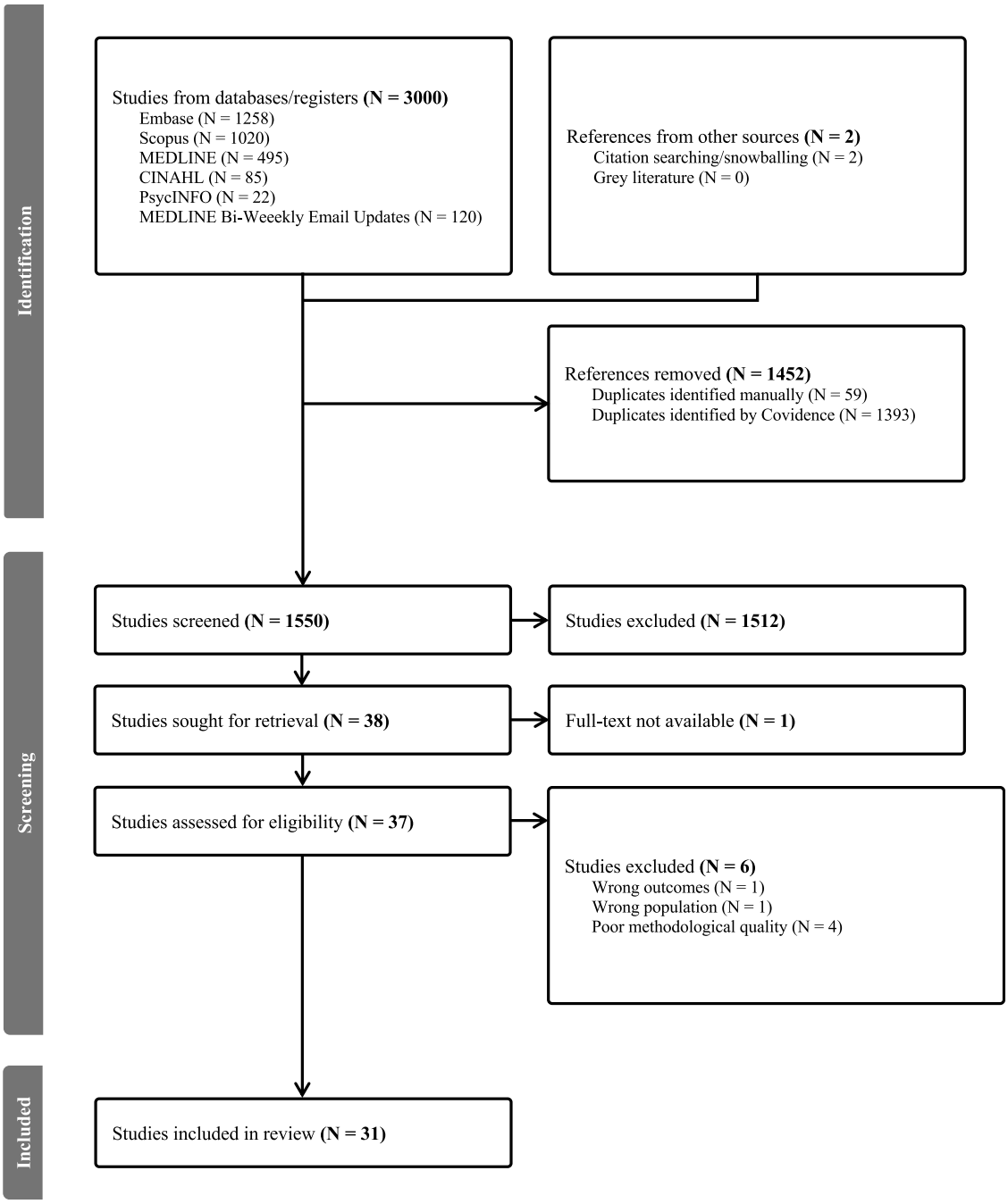

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of study inclusion.

Results

Study characteristics

A total of $N = 3000$ studies were identified through database searches from EMBASE ($N = 1258$), Scopus ($N = 1020$), MEDLINE ($N = 495$), CINAHL ($N = 85$) and PsycINFO ($N = 22$), including an additional $N = 120$ identified via MEDLINE biweekly email updates. Two more studies were identified via snowballing. After duplicates were removed, $N = 1550$ studies underwent title and abstract screening, of which $N = 38$ met eligibility criteria and were sought for full-text retrieval. One full-text study was unavailable leaving $N = 37$ studies for full-text review. Two studies were subsequently excluded for failure to meet inclusion criteria, and four additional studies were also excluded after critical appraisal due to a combination of reasons each contributing to a higher risk of bias. A total of $N = 31$ studies were included for data extraction and synthesis after consensus. The results of the search and the study inclusion process are depicted in Figure 1.

A summary of characteristics of the included studies is presented in Table 1. Of the $N = 31$ included studies, cross-sectional designs were the most common ($N = 16$), followed by retrospective cohorts ($N = 7$) and prospective cohorts ($N = 7$), with only one case-control ($N = 1$). Studies were conducted in 14 different countries, the most common being Germany ($N = 8$),

https://doi.org/10.1017/cjn.2024.273

Table 1. Summary of characteristics of included studies ($N = 31$)

Author (year)	Study design	HRQOL tool	Sample size	Setting	Population	Comparison(s)	Follow-up time	Relevant factor(s) explored	Key findings of significance
Benz et al. (2018)	CC	SF-36	$N = 1722$ cases $N = 1622$ controls	USA	Intracranial MGM after surgery	Healthy controls	Mean = 0.59 yrs after surgery	Radiotherapy Tumour laterality	↓ HRQOL with adjuvant radiotherapy vs. surgery only ↑ rate and severity of symptoms with right-sided vs. left-sided tumours
Castle-Kirszbaum et al. (2022)	PC	ASBQ SNOT-22	$N = 50$	Australia	Anterior skull base MGM undergoing EEA surgery	Before vs. after surgery	ASBQ: Before surgery, 3 wk, 6 wk, 3 mo, 6 mo and 12 mo after surgery SNOT-22: Before surgery, 1 d, 3 d, 7 d, 3 wk, 6 wk, 3 mo, 6 mo and 12 mo after surgery	Age Sex Surgery Tumour size Neurological issues (e.g. visual, olfaction, taste dysfunction, headaches) Degree of resection Previous surgery	↓ preoperative HRQOL with visual dysfunction and ↑ tumour size ↑ preoperative HRQOL with headaches
Fisher et al. (2021)	CS	EORTC QLQ-BN20 SF-36	$N = 173$ MGM (skull base MGM = 89, convexity MGM = 84) $N = 65$ controls	Netherlands	Skull base MGM after surgery and/or radiotherapy ≥ 5 yrs ago	Convexity MGM Informal caregivers (healthy controls)	Median = 9 yrs (range: 5.1–20.8 yrs) after treatment	Tumour location Radiotherapy Previous surgery Surgical complications	↑ HRQOL for anterior/middle vs. posterior skull base MGM ↓ HRQOL with radiotherapy as primary treatment vs. surgery alone
Ganefianty et al. (2020)	CS	EQ-5D-5L EQ-VAS	$N = 118$	Indonesia	MGM after surgery	Normal population data	3 mo–1 yr after surgery	Age Tumour grade Functional status Fatigue Illness perception Social support	↓ postoperative HRQOL with ↑ age, ↑ tumour grade, ↓ functional status, ↑ fatigue, negative illness perception and inadequate social support
Henzel et al. (2013)	PC	SF-36	$N = 52$	Germany	MGM undergoing SRT	German population data Before vs. after SRT	Before SRT, 6, 12, 18 and 24 mo after SRT	Radiotherapy Previous surgery Age Sex Neurological issues	↑ HRQOL in mental component domains at all follow-up intervals with previous operations SRT resulted in temporary ↓ HRQOL during treatment phase in role-physical, role-emotional, vitality, social functioning and pain, with normalization to BL by ≥12 months after treatment SRT resulted in ↑ in mental health and general health domains until end of treatment
Jakola et al. (2012)	PC	EQ-5D KPS	$N = 46$	Norway	Intracranial MGM undergoing surgery	Before vs. after surgery	1–3 d before surgery, 6 wks after surgery (median = 47 d), long term (median = 33 mo, range: 10–58 mo)	Surgery Tumour location Degree of resection Surgical complications Tumour size Age	Significant ↑ in long-term HRQOL after surgery ↓ preoperative HRQOL with skull base MGM vs. other locations

Jones et al. (2016)	RC	ASBQ SNOT-22	$N = 34$	USA	MGM after EEA surgery	Before vs. after surgery	Mean = 42.8 mo (range: 6–106 mo) after surgery	Age Surgery Radiotherapy Degree of resection Recurrence Neurological issues (e.g. visual dysfunction, headaches) Previous surgery	↑ HRQOL with younger age ↓ postoperative sinonasal HRQOL after surgery ↓ HRQOL in pain domain with adjuvant radiotherapy
Kalkanis et al. (2000)	CS	Modified FACT-Br	$N = 155$	USA	Intracranial MGM after surgery	None	Mean = 33 mo (range: 0–165 mo) after surgery	Age Sex Time since surgery Tumour laterality Radiotherapy	↓ HRQOL with ↓ age at time of surgery and interview
Kangas et al. (2012)	CS	FACT-Br FACT-G	$N = 70$	Australia	Primary benign MGM after radiotherapy	PTSS vs. low-PTSS	Mean = 53 mo (range: 2 mo–22.6 yrs) since diagnosis	PTSS Tumour laterality Age Time since diagnosis	↓ HRQOL with PTSS and less time since diagnosis ↓ HRQOL with left-hemisphere vs. right-hemisphere MGM
Karsy et al. (2019)	RC	EQ-5D-5L	$N = 52$	USA	Skull base MGM after surgery	Before vs. after surgery	Mean = 9.1 ± 7.9 mo after surgery First follow-up = 1.2 ± 0.02 mo Second follow-up = 11.1 ± 10.8 mo	Surgery Age Recurrence Sex Neurological issues (e.g. optic nerve compression, proptosis) Surgical approach Surgical complications	↑ HRQOL at 1 yr with female sex, absence of proptosis, non-frontotemporal approaches, no optic nerve decompression and absence of surgical complications
Keshwara et al. (2022)	CS	EORTC QLQ-BN20 EORTC QLQ-C30 SF-36	$N = 243$	UK	Incidental, actively monitored or surgically treated MGM	Normal population data	Mean = 9.8 ± 22.2 yrs (range: 5.0–40.3 yrs) from diagnosis	Sex Education Employment Surgical complications Radiotherapy Previous surgeries Comorbidities Tumour location Tumour laterality Number of AEDs Functional status Time since diagnosis	↑ HRQOL with male sex, greater education and employment ↓ HRQOL with postoperative complications, comorbidities, functional status
Kofoed Lauridsen et al. (2022)	CS	FACT-Br FACT-G	$N = 45$	Denmark	Subfrontal MGM after bifrontal craniotomy	Normal population data GBM/other MGM types	Mean = 7.1 yrs after surgery	Symptoms Discharge site PTBE Tumour size Tumour grade Time since surgery Previous surgery Recurrence Surgical complications	↑ long-term HRQOL with fewer symptoms at diagnosis and home as discharge location

(*Continued*)

Table 1. Summary of characteristics of included studies ($N = 31$) (*Continued*)

Author (year)	Study design	HRQOL tool	Sample size	Setting	Population	Comparison(s)	Follow-up time	Relevant factor(s) explored	Key findings of significance
Krupp et al. (2009)	CS	Questions of Life Satisfaction Survey	$N = 91$	Germany	Supratentorial MGM after surgery	None	Mean = 15 ± 3.6 mo (range: 10.0–18.5 mo) after surgery	Age Sex Marital status	↓ life satisfaction reported in single men vs. single women ↓ life satisfaction reported in younger patients <55 yr and patients of single status
Lin et al. (2021)	CS	EORTC QLQ-BN20 EORTC QLQ-C30	$N = 44$ MGM $N = 33$ PT	Northern Taiwan	MGM or PT prior to treatment	None	Not reported	Sleep	↑ HRQOL with ↑ sleep quality
Lisowski et al. (2022)	RC	EORTC QLQ-BN20 EORTC QLQ-C30 KPS	$N = 49$	Germany	Intracranial MGM after radiotherapy	Previous cohort data	Median = 4.8 yrs (IQR 2.7–9.2 yrs) after radiotherapy	Radiotherapy Tumour location	↓ on functional scales for physical, role, cognitive, social functioning ↑ on symptom scales for fatigue, pain, dyspnoea, insomnia, constipation, financial impact
Meixensberger. et al. (1996)	RC	KPS	$N = 385$	Germany	Cranial MGM after surgery	Before vs. after surgery	Before surgery, 30 d, 6 mo after surgery	Age Tumour size Tumour location Tumour grade Surgical complications Neurological issues (e.g. cranial nerve disturbances) Symptoms Comorbidities	↓ postoperative HRQOL with intra-/postoperative bleeding, CSF disturbances, cranial nerve disturbances and cardiac disease ↑ postoperative HRQOL with initial symptoms of intracranial hypertension, seizures, aphasia and hemiparesis
Nassar et al. (2022)	RC	KPS	$N = 65$	Ukraine	Sphenoid wing MGM after surgery	Before vs. after surgery PTBE vs. no PTBE	Median = 86 mo (range: 6– 156 mo) after discharge	PTBE	↓ HRQOL at 3 mo post-surgery with PTBE vs. no PTBE
Nassiri et al. (2019)	PC	EORTC QLQ-C30	$N = 291$	Australia	MGM after surgery	Normal population data 12 mo intervals post-surgery	Median = 37 mo from surgery to completion of first survey Follow-up at 12, 48, 108 and 120 mo	Time since surgery Fatigue Emotional function Pain Social function Cognitive function Physical function Sleep	↓ HRQOL with ↑ fatigue, ↓ emotional function, ↓ social function and ↑ pain ↓ HRQOL at 12 mo post-surgery with ↓ cognitive function, ↓ physical function, ↑ sleep disturbance

Ouyang et al. (2015)	RC	KPS	$N = 53$	China	Sphenoid wing MGM after microsurgery	Before vs. after surgery	Median = 34 mo (range: 6–62 mo) from surgery to follow-up	Degree of resection Tumour complexity (e.g. adhesion, encasement, blood supply) Age Sex Tumour location Tumour size Neurological issues (e.g. headache, visual acuity) Functional status Surgical approach PTBE	↓ postoperative HRQOL improvement with complete resection, adhesion to adjacent structures, encasement of neurovascular structures, rich blood supply
Pettersson-Segerlind et al. (2021)	CS	EQ-5D	$N = 84$ patients $N = 252$ controls	Sweden	Spinal MGM after surgery	Normal population data	Mean = 8.7 yrs from surgery to follow-up	Sex Time since surgery Neurological function	↓ HRQOL in mobility domain with female sex and ↓ postoperative neurological function
Pintea et al. (2018)	RC	SF-36	$N = 58$	Germany	PCM and LPPM after surgery	German population data PCM vs. LPPM	Median = 59 mo for all patient groups (range: 1–24 mo), 64 mo for LPPM and 67 mo for PCM	Sex Neurological issues (e.g. hypoacusis/anacusis, swallowing disturbances, hemiparesis/hemiataxia) Functional status	↓ HRQOL in pain domain with female sex ↓ HRQOL in vitality domain with hypoacusis/anacusis and ↓ KPS at discharge ↓ HRQOL in physical functioning domain with swallowing disturbances ↓ HRQOL in physical functioning, social functioning, vitality and physical component domains with hemiparesis/hemiataxia
Tanti et al. (2017)	CS	SF-36 FACT-BR	$N = 229$ (N = 109 MGM without epilepsy; $N = 56$ MGM with epilepsy; $N = 64$ epilepsy without MGM)	UK	MGM with epilepsy after surgery	MGM without epilepsy + epilepsy without MGM USA population data	Median = 3.9 yrs (range: 0.8–11.5 yrs) after surgery	AED use Unemployment Neurological issues Sex Epilepsy/seizures Comorbidities Recurrence	↓ HRQOL with epilepsy, AED use, depression, diabetes, unemployment and presence of meningioma complications
Timmer et al. (2019)	CS	SF-36	$N = 133$	Germany	MGM after surgery	Age groups at 5 yrs intervals	Mean = 3.8 ± 2.5 yrs from surgery and questionnaire completion	Age Comorbidities Functional status Time since surgery	75–79 yr age group had ↓ HRQOL in physical function domain compared to younger age groups ↓ HRQOL with ↑ severity of comorbidities ↑ HRQOL with ↑ functional status
Torales et al. (2024)	PC	SF-36	$N = 20$ (N = 10 SO surgery; $N = 10$ EEA surgery)	Spain	PS and TS MGM after SO or EEA surgery	SO vs. EEA surgery	Mean = 40.17 mo (range: 3–60 mo) after surgery HRQOL assessed 12 mo after surgery	Surgical approach	No statistically significant associations found
Waagemans et al. (2011)	CS	SF-36	$N = 87$	Netherlands	WHO grade I MGM after surgery and/or radiotherapy	Matched healthy controls	Mean = 3.4 ± 2.0 yrs after treatment	Neurological function AED use Degree of resection	↓ HRQOL in role-physical, social functioning, mental health, vitality and general health domains with AED use ↓ HRQOL in physical functioning, role-physical, role-emotional, general health, vitality, social functioning and mental health scores and bodily pain domains with ↓ executive functioning

(*Continued*)

Table 1. Summary of characteristics of included studies ($N = 31$) (*Continued*)

Author (year)	Study design	HRQOL tool	Sample size	Setting	Population	Comparison(s)	Follow-up time	Relevant factor(s) explored	Key findings of significance
Wagner et al. (2019)	PC	SF-36 EQ-5D-5L	$N = 71$	Germany	Intracranial MGM undergoing surgery	Before vs. after surgery	Before surgery, 3 mo and 12 mo after surgery	Psychological impairment Surgery Tumour location Neurological function	↓ HRQOL in mental component domains with ↑ preoperative anxiety, depression and PTSS at 3 mo follow-up ↑ HRQOL in mental component domains with ↑ neurological function
Wirsching et al. (2020)	CS	EORTC QLQ-C30 EORTC QLQ-BN20	$N = 249$	Switzerland	MGM after surgery	Before vs. after surgery	≥1 yr after surgery	Subjective work ability Employment status Social deprivation Workload Income Education level Surgery Age Sex Tumour grade Tumour size Tumour location	↓ HRQOL with ↓ subjective work ability and preoperative employment
Zamanipoor Najafabadi et al. (2021a)	CS	SF-36 EORTC QLQ-BN20	$N = 190$ patients $N = 129$ controls	Netherlands	Intracranial MGM after surgery and/or radiotherapy	Normal population data Informal caregivers (healthy controls)	Median = 9 yrs (IQR: 7–12 yrs) after treatment	Active surveillance	↓ HRQOL in role-physical and role-emotional domains vs. informal caregivers ↓ HRQOL in role-physical and physical component domains vs. normative data
Zamanipoor Najafabadi et al. (2021b)	CS	SF-36	$N = 190$ patients	Netherlands	Intracranial MGM after surgery and/or radiotherapy	None	Median = 9 yrs (IQR: 7–12 yrs) after treatment	Comorbidities Functional status Education level Tumour size Tumour location Sex Surgical complications Previous surgery Radiotherapy	↓ HRQOL in physical component domains with female sex, ↑ comorbidities, ↓ KPS, ↓ education levels, ↑ pre-participation, ↑ tumour size ↓ HRQOL in mental component domains with ↓ KPS
Zhang et al. (2022)	CS	SF-36	$N = 100$	China	MGM prior to treatment	With vs. without sleep disturbance	Median = 7 d (IQR: 7–30 d) from time since diagnosis to participation	Sleep	↓ HRQOL and ↓ scores in role-physical, bodily pain, general health, vitality, social functioning, role-emotional and mental health in patients with sleep disturbance vs. without sleep disturbance
Zweckberger et al. (2019)	PC	EORTC QLQ-C30	$N = 58$	Germany	Skull base MGM undergoing surgery	Before vs. after surgery	Mean = 13.8 mo from surgery to follow-up 1 d before surgery, 3–5 mo and 9–12 mo after surgery	Surgery Age Tumour size Tumour location Neurological issues	↓ HRQOL at 1 d after surgery, but HRQOL recovered to slightly ↑ levels by 12 mo after surgery

Notes: AED = antiepileptic drug; ASBQ = Anterior Skull Base Questionnaire; BL = baseline; CC = case-control; CS = cross-sectional; CSF = cerebrospinal fluid; EEA = endoscopic endonasal approach; EORTC QLQ-BN20 = European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Brain Neoplasm 20; EORTC QLQ-C30 = European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Core 30; EQ-5D = EuroQOL-5 Dimensions; FACT-Br = Functional Assessment of Cancer Therapy-Brain; FACT-G = Functional Assessment of Cancer Therapy-General; GBM = glioblastoma patients; HRQOL = health-related quality of life; IQR = interquartile range; KPS = Karnofsky performance scale; LPPM = lateral posterior surface of the pyramid meningioma patients; MGM = meningioma patients; PC = prospective cohort; PCM = petroclival meningioma patients; PS = planum sphenoidale; PT = pituitary tumour patients; PTBE = peritumoural brain oedema; PTSS = post-traumatic stress symptoms; RC = retrospective cohort; SF-36 = 36-item Short Form Survey; SNOT-22 = Sinonasal Outcome Test 22; SO = supraorbital; SRT = stereotactic radiotherapy; TS = tuberculum sellae; UK = United Kingdom; USA = United States of America; VAS = Visual Analogue Scale; WHO = World Health Organization; ↑= increase(d); ↓= decrease(d).

USA ($N = 4$), the Netherlands ($N = 4$) and Australia ($N = 3$). The HRQOL of meningioma patients was compared to healthy controls in four studies and normative population data in eight. Pre-treatment HRQOL data were compared to post-treatment data in 11 studies of which one involved comparisons to both normative and preoperative data. Other studies included HRQOL comparisons based on different meningioma locations, different brain tumours, previous cohorts and on the basis of age, surgical approach, psychological impairments, epilepsy and sleep disturbance. Five studies reported HRQOL results of meningioma patients without any comparisons to other groups.

Over one-third of studies ($N = 11$) included patients with all types of meningioma, typically without reporting results by specific location. The majority of the remaining studies specifically focused on meningiomas of intracranial ($N = 8$), skull base ($N = 5$) or sphenoid wing ($N = 2$) locations. In terms of treatment, 21 studies included patients post-surgery, and only three focused solely on radiotherapy. Six focused on surgery and/or radiotherapy, two on patients prior to treatment and one on patients in any treatment phase.

HRQOL of meningioma patients

In addition to factor-specific findings, several studies also examined the overall status of HRQOL in meningioma patients compared to healthy populations ($N = 11$).[15–25] Although not a focus of our review, the results provide important context for our findings, suggesting that meningioma patients as a whole tend to experience inferior HRQOL in cognitive functioning, general health and vitality and most notably in role-physical, role-emotional and social functioning[15–19] compared to healthy populations, irrespective of any treatment-related improvements.

Factor-specific findings

Tables 2, 3 and 4 present key findings from the included studies related to patient-, tumour- and treatment-related factors, respectively. A detailed summary of results is provided in Supplementary Appendices II–IV. Statistically significant or clinically relevant results are presented here.

Patient-related factors

Various patient-related factors and their associations with HRQOL in meningioma patients were explored across studies. Three of five studies on **comorbidities** evaluated severity using scales such as the American Society of Anesthesiologist classification and Charlson Comorbidity Index,[18,26,27] while the others looked at the effect of a certain comorbidity. In one study, cardiac disease specifically was associated with lower postoperative HRQOL,[28] and another found that diabetes was associated with lower 36-item Short Form Survey physical component scale (SF-36 PCS), mental component scale (MCS) and Functional Assessment of Cancer Therapy (FACT) scores.[29] Although cohesive deductions could not be made due to heterogeneity in the scales used, the presence of severe comorbidities appears to be consistently associated with inferior HRQOL.

Functional status, primarily assessed using the Karnofsky Performance Scale (KPS), was found to influence HRQOL across six studies. Five studies reported a positive association between functional status and postoperative HRQOL, with four specifically finding that patients with higher KPS scores tended to have better SF-36 PCS and MCS scores.[15,20,26,27] One study found a negative association between preoperative, as opposed to postoperative, KPS score and postoperative HRQOL.[30] This finding mirrors other work where patients with higher preoperative HRQOL tended towards worsening scores post-surgery.[31]

Two studies exploring **fatigue** found a significant negative association with postoperative HRQOL. In one study, greater fatigue was associated with lower postoperative EuroQOL-5 Dimension (EQ-5D) scores on univariate analysis,[20] and another demonstrated a strong correlation between increased fatigue and lower global HRQOL across all follow-up time points.[19]

In terms of the impact of **sleep,** greater sleep quality was associated with better HRQOL[32] and increased sleep disturbance was associated with worse HRQOL[19] as assessed by the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ) tools. Another study found that patients with sleep disturbance had lower PCS and MCS scores and lower scores in all individual domains of SF-36, except for physical functioning.[33]

Three studies[29,34,35] examined the influence of **psychological impairment** on HRQOL in meningioma patients. One investigated the influence of abnormal preoperative anxiety, post-traumatic stress symptoms (PTSS) and depression scores on HRQOL before and after surgery and found that they were associated with decreased EuroQOL-5 Dimension 5 Level (EQ-5D-5L) and SF-36 scores.[34] Similarly, another found that elevated PTSS scores were associated with reduced physical, emotional and functional well-being[35]. Depression was found to be associated with reduced MCS scores on SF-36.[29,34]

The impact of **illness perception** on HRQOL in meningioma patients was explored in one study[20], which found negative illness perception to be associated with decreased EQ-5D scores. Likewise, the absence of **social support** was linked with compromised HRQOL.[20] Indirect insights on social support also emerge from Krupp et al.'s work exploring the influence of marital status on HRQOL, which may serve as a proxy for social support. Their findings suggest that patients who are single express lower life satisfaction compared to those in marital or partnered relationships.[36]

Several **other patient-reported outcomes** were examined by a limited number of studies. Headaches at presentation were associated with increased preoperative HRQOL in one study,[37] but others found no relationship.[30,38,39] Lower global HRQOL correlated with decreased cognitive, physical and social function and increased pain.[19]

Mixed results emerged across 14 studies examining the impact of **age** on HRQOL.[20,25,26,28,30,31,35–42] Interestingly, three studies determined that younger age was associated with worse HRQOL[25,36,42] regarding extended recovery, lower self-esteem and reduced life satisfaction. Other studies, however, found that older age was associated with varying degrees of inferior HRQOL.[20,26,38] Specifically, one found that individuals aged >75 exhibited worse physical functioning scores.[26] Most studies compared age by dichotomizing participants as above or below the mean or median age, and those finding significant associations often had a broader age range beginning in the 20s, suggesting that differences in HRQOL may become more apparent with wider ranges.

The influence of **sex or gender** on HRQOL was assessed in 12 studies.[15,18,22,25,27,29,30,36,37,39,40,42] Among these, four found that females generally exhibited lower HRQOL scores compared to males, both on a global scale and within specific domains such as physical functioning and mobility, while also reporting higher

https://doi.org/10.1017/cjn.2024.273

Table 2. Summary of patient-related factors explored and their association with health-related quality of life (HRQOL)

Factor	Results
Comorbidities	↑ comorbidities associated with ↓ HRQOL[18] Cardiac disease associated with ↓ postoperative HRQOL[28] Diabetes associated with ↓ HRQOL, but no association between the number of comorbidities and HRQOL[29] ASA Class IV associated with ↓ HRQOL in physical functioning, role-physical, role-emotional, vitality, general health and bodily pain domains[26] ↑ comorbidities associated with ↓ HRQOL in physical component domains[27]
Functional status	↓ functional status associated with ↓ postoperative HRQOL[20] ↓ WHO performance status associated with ↓ HRQOL[18] ↑ preoperative KPS associated with ↓ postoperative HRQOL[30] ↓ KPS at discharge associated with ↓ HRQOL in vitality domain[15] ↑ functional status associated with ↑ postoperative HRQOL in physical functioning, physical role functioning, bodily pain, emotional role functioning and general health domains[26] ↓ KPS associated with ↓ HRQOL in mental and physical component domains[27]
Fatigue	↑ fatigue associated with ↓ postoperative HRQOL[20] ↑ fatigue at 12, 48, 108, 120 mo post-surgery associated with ↓ global HRQOL[19]
Sleep disturbance	↑ sleep quality associated with ↑ HRQOL[32] Sleep disturbance associated with ↓ global HRQOL at 12 mo post-surgery[19] Sleep disturbance associated with ↓ HRQOL in mental and physical component domains, including role-physical, pain, general health, vitality, social functioning, role-emotional and mental health[33]
Psychological impairment	↑ PTSS associated with ↓ HRQOL in physical, emotional and functional well-being domains[35] Depression associated with ↓ HRQOL[29] Prior psychiatric therapy and abnormal anxiety/depression scores associated with ↓ preoperative HRQOL[34] ↑ preoperative anxiety, depression and PTSS associated with ↓ HRQOL in mental component domains at 3 mo post-surgery[34] Abnormal scores on STAI-S, STAI-T, ADS and PTSS-10 scales associated with ↓ HRQOL at 12 mo post-surgery[34]
Illness perception	Negative illness perceptions associated with ↓ postoperative HRQOL[20]
Social support	Inadequate social support associated with ↓ postoperative HRQOL[20]
Other PROs	Headache at presentation associated with ↑ preoperative HRQOL[37] ↓ emotional function, ↑ pain, and ↓ social function at 12, 48, 108, 120 mo post-surgery and ↓ cognitive function and ↓ physical function at 12 mo post-surgery associated with ↓ global HRQOL19 *N = 3 studies showed no significant associations*[30,39,41]
Age	↑ age associated with ↓ postoperative HRQOL[20] Age<55 yr associated with ↑ HRQOL in performance and specific symptoms domains[39] ↓ age at surgery and time of follow-up associated with ↓ HRQOL[25] No association between age and general life satisfaction, but patients <55 yr qualitatively reported longer recovery, lower self-esteem, lower life satisfaction[36] Age 75–79 yr group had ↓ HRQOL in physical functioning domain compared to younger age groups[26] ↑ age groups associated with ↓ HRQOL in physical component domains, but no significant differences in mental component domains among different age groups[26] ↓ age associated with ↓ HRQOL[42] *N = 8 studies showed no significant associations*[28,30,31,35,37,38,40,41]
Sex	Female sex associated with ↑ HRQOL at 1 yr[41] Male sex associated with ↑ HRQOL[18] Female sex associated with ↓ HRQOL in mobility domain[22] Female sex associated with ↓ HRQOL in pain domain[15] Female sex associated with ↓ HRQOL in physical component domains[27] Single males reported ↓ life satisfaction compared to single females[36] *N = 6 studies showed no significant associations*[25,29,30,37,38,42]
Other sociodemographics	Single status associated with ↓ life satisfaction compared to married/having a partner[36] ↓ subjective work ability associated with ↓ HRQOL, but no association between low income, workload, or social deprivation and HRQOL[42]
Employment status	Unemployment associated with ↓ HRQOL[29] Preoperative unemployment associated with ↓ HRQOL[42]
Education level	↑ education level associated with ↑ HRQOL[18] ↓ education level associated with ↓ HRQOL in physical component domains[27] *N = 1 study found no significant association*[42]

Notes: ADS = Allgemeine Depressionsskala; ASA = American Society of Anesthesiologists; KPS = Karnofsky performance scale; PROs = patient-reported outcomes; PTSS-10 = Post-traumatic Symptom Scale-10 items; STAI-S = State-Trait Anxiety Inventory-State; STAI-T = State-Trait Anxiety Inventory-Trait; WHO = World Health Organization; ↑= increase(d); ↓= decrease(d).

levels of pain.[15,22,27,39] In another study, single men were found to report lower life satisfaction than single women. However, when assessing sex independently, no statistically significant differences were observed between males and females.[36] Six of the 12 studies failed to establish any significant link between sex and HRQOL in meningioma patients.[25,29,30,37,40,42] Differences in participant characteristics, treatment phases and HRQOL assessment tools, however, make it challenging to directly compare all 12 studies.

https://doi.org/10.1017/cjn.2024.273

Table 3. Summary of tumour-related factors explored and their association with health-related quality of life (HRQOL)

Factor	Results
Tumour size	↑ tumour size associated with ↓ preoperative HRQOL[37] ↑ tumour size associated with ↓ postoperative HRQOL[30] ↑ tumour size before study participation associated with ↓ HRQOL in physical component domains, but no association between tumour size before treatment and HRQOL[27] *N = 5 studies showed no significant associations*[24,28,31,40,42]
Tumour location	Anterior/middle skull base MGM associated with ↑ HRQOL in physical role functioning, motor dysfunction, communication deficit and weakness in both legs domains compared to posterior skull base MGM[23] No significant differences between convexity and skull base MGM[23] Skull base MGM associated with ↓ preoperative HRQOL compared to other locations, but no association between tumour location and postoperative HRQOL[31] *N = 8 studies showed no significant associations*[18,27,28,30,34,40,42,43]
Tumour laterality	Right-sided tumours associated with ↑ rate and severity of symptoms compared to left-sided tumours[16] Left-sided tumours associated with ↓ HRQOL in functional well-being domain compared to right-sided tumours[35] *N = 2 studies showed no significant associations*[18,25]
Histologic grade	↑ tumour grade associated with ↓ postoperative HRQOL[20] *N = 2 studies showed no significant associations*[28,42]
Other tumour characteristics	Adhesion to adjacent structures, encasement of neurovascular structures and rich blood supply associated with ↓ postoperative HRQOL improvement[30]
Peritumoural brain oedema	PTBE associated with ↓ HRQOL scores at 3 mo post-surgery[44] PTBE associated with ↓ postoperative HRQOL[30] *N = 1 study showed no significant associations*[24]
Epilepsy	MGM patients with epilepsy associated with ↓ HRQOL in all domains except bodily pain compared to those without epilepsy[29] Epilepsy and seizures in past 6 mo not associated with ↓ HRQOL[29]
Sensory dysfunction	Visual dysfunction associated with ↓ preoperative HRQOL[37] Visual improvement associated with ↑ HRQOL at 6 mo post-surgery[37] No association between olfaction/taste and overall postoperative HRQOL[37] Hypoacusis/anacusis associated with ↓ HRQOL in vitality domain[15] *N = 3 studies showed no significant associations*[30,39,41]
Neurological function	↓ postoperative neurological function associated with ↓ HRQOL in mobility domain[22] ↓ executive functioning associated with ↓ HRQOL in physical functioning, role-physical, role-emotional, general health, vitality, social functioning, mental health and bodily pain domains[21] ↑ postoperative neurological function associated with ↑ HRQOL in mental component domains[34]
Other neurological issues	Absence of optic nerve decompression and proptosis associated with ↑ HRQOL at 1 yr[41] Initial presentation with intracranial hypertension, seizures, aphasia and hemiparesis associated with ↑ postoperative HRQOL[28] Swallowing disturbances and hemiparesis/hemiataxia associated with ↓ HRQOL in physical functioning, vitality, social functioning and physical component domains[15] ↑ MGM complications and motor/sensory issues associated with ↓ HRQOL[29] *N = 2 studies showed no significant associations*[40,42]
Symptoms	↓ symptoms at diagnosis associated with ↑ long-term HRQOL[24] *N = 1 study showed no significant associations*[38]
Time since diagnosis	↓ time since initial diagnosis associated with ↓ overall HRQOL[35] *N = 1 study showed no significant associations*[18]
Recurrence	*N = 4 studies showed no significant associations*[24,29,39,41]

Notes: MGM = meningioma; PTBE = peritumoural brain oedema; ↑= increase(d); ↓= decrease(d).

Employment status was associated with HRQOL in three studies.[18,29,42] Using multivariate regression analysis, each study found a statistically significant association between unemployment and inferior HRQOL scores. This finding was observed when evaluating the influence of preoperative[42] and postoperative employment status on EORTC QLQ scores.[18,29]

Education level was evaluated by three studies, of which two found a statistically significant association with HRQOL.[18,27,42] One found lower education level to be a determinant for a decreased PCS on SF-36,[27] and the other noted higher education levels were significantly associated with overall better EORTC QLQ-C30 scores.[18] Both of these studies were focused on long-term HRQOL outcomes following diagnosis and treatment of meningioma. The study failing to find a significant association was potentially influenced by recall bias due to retrospective interrogation.[42] The categories used to define educational level also varied between studies, potentially influencing the findings.

Tumour-related factors

The effect of **tumour size** on HRQOL was investigated across eight studies.[24,27,28,30,31,37,41,42] Only three reported a significant association, and no trends were observed. Greater tumour size was associated with lower preoperative HRQOL via Anterior Skull Base Questionnaire (ASBQ)[37] and lower postoperative HRQOL via KPS in univariate, but not multivariate, analysis.[30] One study found that greater tumour size before study participation was associated with lower PCS via SF-36.[27]

https://doi.org/10.1017/cjn.2024.273

Table 4. Summary of treatment-related factors explored and their association with health-related quality of life (HRQOL)

Factor	Results
Surgery	Surgery associated with temporary ↓ sinonasal-specific and generic HRQOL with gradual return to BL 3–6 weeks postoperatively[37] Surgery associated with modest ↑ in HRQOL in the early postoperative period and long term[31] ↑ preoperative HRQOL associated with ↓ HRQOL after surgery[31] Surgery associated with stable or slightly ↑ generic HRQOL but ↓ postoperative sinonasal-specific HRQOL[38] Surgery associated with ↑ HRQOL in role-physical and role-emotional functioning at 12 mo[34] Surgery associated with ↑ HRQOL in global health, headaches and seizures and <10% ↑ in emotional and social functioning, future uncertainty, nausea and vomiting, pain, appetite loss, visual disorder and motor dysfunction scores ≥ 1 yr postoperatively[42] No significant change in HRQOL at 3–5mo post-surgery but HRQOL ↑ to slightly higher levels than preoperatively at 9–12 mo[41] *N = 1 study found no significant associations*[39]
Time since surgery	↑ HRQOL beyond preoperative BL at ≥6 mo and 1 yr postoperatively[37] *N = 5 studies found no significant associations*[19,22,24–26]
Previous surgery	Previous surgery associated with ↑ HRQOL in mental component domains compared to primary SRT[40] Primary SRT associated with ↓ HRQOL in physical component domains initially but reached similar levels to previous operations cohort over time[40] *N = 6 studies found no significant associations*[18,23,24,27,37,38]
Extent of resection	Complete resection associated with ↓ postoperative HRQOL improvement[30] *N = 4 studies found no significant associations*[21,31,37,38]
Surgical approach	Non-frontotemporal approaches associated with ↑ HRQOL at 1 yr[39] *N = 2 studies found no significant associations*[30,45]
Radiotherapy	Radiotherapy associated with ↓ HRQOL in vitality, role-physical, social functioning compared to surgery alone[16] Radiotherapy as initial treatment associated with ↓ HRQOL in bodily pain and vitality compared to surgery as initial treatment[23] No difference in HRQOL between patients treated with only surgery vs. surgery + adjuvant radiotherapy[23] No difference in HRQOL between patients treated with surgery + adjuvant radiotherapy vs. radiotherapy as initial treatment[23] SRT associated with temporary ↓ HRQOL during treatment phase in role-physical, role-emotional, vitality, social functioning and pain, with normalization to BL by ≥12 mo after treatment[40] SRT associated with in ↑ in mental health and general health domains until the end of treatment[40] Adjuvant radiotherapy associated with ↓ scores in pain domains[38] Radiotherapy associated with ↓ HRQOL in physical, role, cognitive and social functioning and fatigue, pain, dyspnoea, insomnia, constipation, financial impact[43] No difference in median KPS score before and after radiotherapy[43] Sequential radiotherapies not significantly associated with global health status[43] *N = 3 studies found no significant associations*[18,25,27]
Discharge destination	Discharge to home associated with ↑ long-term HRQOL[24]
Active surveillance	*N = 1 study found no significant associations*[17]
Surgical complications	Absence of surgical complications associated with ↑ HRQOL at 1 yr[39] Postoperative complications associated with ↓ HRQOL[18] Intra/postoperative bleeding, cranial nerve disturbances and CSF disturbances associated with ↓ postoperative HRQOL[28] *N = 4 studies found no significant associations*[23,24,27,31]
AED use	AED use associated with ↓ overall HRQOL and mental component domains compared to no AED use[29] AED use associated with a greater ↓ in HRQOL than recent seizures[29] AED use associated with ↓ HRQOL in role-physical, social functioning, mental health, vitality and general health, but no correlation in most domains when executive functioning controlled for[21] *N = 1 study found no significant associations*[18]

Notes: AED = antiepileptic drug; BL = baseline; CSF = cerebrospinal fluid; KPS = Karnofsky performance scale; SRT = stereotactic radiotherapy; ↑ = increase(d); ↓ = decrease(d).

Ten studies[18,23,27,28,30,31,34,41–43] evaluated **tumour location** as a potential factor affecting HRQOL, with only one showing any significant association. Specifically, posterior skull base locations were linked to compromised role functioning, motor dysfunction, communication deficits and leg weakness compared to anterior/middle locations.[23] This study explored specific localizations within skull base meningiomas,[23] while the others only compared findings from skull base meningiomas to other broader categories of locations such as frontal or convexity meningiomas. This discrepancy suggests that the impact of tumour location on HRQOL might be more nuanced and context-dependent, though more uniform evaluation is needed.

Regarding **tumour laterality**, two of four studies[16,18,25,35] found significant associations with HRQOL, though conflicting findings were reported. One study linked right-sided tumours and impaired HRQOL,[16] whereas the other study identified a comparable association with left-sided tumours.[35] Differences in intervention type, follow-up period, study design and HRQOL metrics used may have contributed to differing results.

Among three studies exploring the impact of **histologic grade** on HRQOL,[20,28,42] a significant univariate association was found in only one.[20] The other two studies reported either minimal data[28] or acknowledged potential selection bias in favour of patients with lower WHO grade meningiomas.[42]

Other tumour characteristics, including adhesion of the tumour to surrounding structures, tumour encasement and tumour blood supply, were found to be associated with KPS scores by a single study.[30] However, the overall effect of these particular characteristics is difficult to ascertain due to a lack of corroborating evidence from additional studies.

https://doi.org/10.1017/cjn.2024.273

The possible influence of various meningioma complications on HRQOL was investigated across several studies. **Peritumoural brain oedema** (PTBE) was investigated in three,[24,30,44] two of which found the presence of PTBE to be negatively associated with postoperative HRQOL. For one study, the association was found only in univariate analysis.[30] Another revealed lower KPS scores at three months post-surgery in patients with preoperative PTBE.[44] As cohort studies, both lacked sufficient information regarding patient follow-up and used KPS to measure HRQOL, which may be a limitation as the KPS tool is a non-specific measure of HRQOL focusing on functional status. Furthermore, both studies focused on sphenoid wing meningiomas, limiting the generalizability of results to other locations.

It is difficult to make conclusive remarks on **epilepsy** and **sensory dysfunction** as potential determinants of HRQOL as significant results were only obtained from single studies. One study found that surgically treated meningioma patients with epilepsy had impaired HRQOL scores on the Functional Assessment of Cancer Therapy-Brain (FACT-Br) and in all domains of SF-36, except for bodily pain, compared to those without epilepsy.[29] Visual dysfunction was associated with lower preoperative HRQOL,[30] and hypo- or anacusis was associated with lower vitality scores.[15] More research is required as associations between visual, olfactory and gustatory dysfunction and postoperative HRQOL were not consistently studied.

Three studies[21,22,34] evaluated the effect of **neurological function** on postoperative HRQOL, all finding a statistically significant positive association. Decreased postoperative neurological function measured via modified McCormick scale grade was associated with lower scores in the EQ-5D mobility domain,[22] and lower executive functioning was associated with lower scores on all SF-36 domains, except for bodily pain.[21] Wagner et al. explored improvements in neurological function as a potential factor and discovered greater improvements to be associated with better MCS values on SF-36.[34]

A range of **other neurological problems** were linked to worse postoperative HRQOL in four separate studies.[15,28,29,39] These issues included optic nerve compression,[39] proptosis,[39] intracranial hypertension,[28] hemiparesis,[15,28] hemiataxia,[28] seizures[28], aphasia,[28] swallowing disturbances[15] and motor/sensory deficits.[29] However, these findings mainly emerged in individual studies and would benefit from additional research to solidify their validity. Other research examining more broadly the effects of preoperative neurological symptoms[41] and postoperative neurological deficits[42] failed to find connections, rendering the impact of these various neurological problems on HRQOL uncertain.

Evidence for the clinical factors of **symptoms** and **time since diagnosis** was insufficient to allow for proper prognostic assessment.

Finally, four studies exploring **tumour recurrence** as a factor affecting HRQOL failed to find any significant associations.[24,29,38,39] However, to draw definitive conclusions, larger-scale prospective research is warranted, given that the current findings predominantly stem from small, cross-sectional and retrospective cohorts.

Treatment-related factors

Seven studies[31,34,37–39,41,42] evaluated the effect of **surgical resection** on HRQOL in meningioma patients. All but one[39] found a statistically significant difference between HRQOL values before and after surgery. HRQOL tended to be worse in the immediate postoperative period before returning to preoperative levels in the first several weeks following surgery and continuing to improve long term.[31,37,41] While patients still had worse on average HRQOL compared to healthy populations, surgery appears to have a beneficial effect on long-term HRQOL. Domains of HRQOL most improved at one-year post-surgery include headaches, seizures, role limitations due to physical problems and role limitations due to emotional problems.[34,42] Notably, one study found patients with better preoperative scores tended to report postoperative worsening of HRQOL scores.[31] Further research examining this possible association is warranted.

Six studies[19,22,24–26,37] evaluated **time since surgery** as a distinct factor impacting HRQOL, with only one[37] noting a significant association. Unlike the other 5 studies with follow-up periods exceeding 12 months post-surgery, this study conducted follow-up immediately after surgery and at varying intervals up to one-year post-operation. It found that ASBQ scores increased beyond preoperative baseline after six months and one-year postoperatively.[37] This suggests that the relevance of time since surgery might be more pronounced when considering the initial year following the procedure, whereas its influence on HRQOL may weaken beyond that point. This is supported by the aforementioned trends in studies looking at HRQOL after surgical resection.

Seven studies examined whether there was an association between **previous surgical resection** and HRQOL,[18,23,24,27,37,38,40] though differences in the specific variables assessed were present. One study with potential bias issues found that patients with previous surgical resection receiving stereotactic radiotherapy (SRT) tended to have better MCS results as compared to patients receiving primary SRT,[40] and the remaining found no association between the number of surgeries or previous resection and HRQOL.[18,23,24,27,37,38]

Findings regarding the long-term impact of the **extent of resection** on HRQOL predominantly indicated no association,[21,31,37,38] with only one study focused on sphenoid wing meningiomas finding that complete resection was associated with a decreased improvement in postoperative HRQOL via KPS.[30]

Three studies examined the impact of the **surgical approach** on HRQOL in meningioma patients, but they have limited comparability due to different scopes.[30,39,45] One study focused on sphenoid wing meningiomas and found no significant differences in KPS scores among three specific surgical approaches.[30] Another study focusing on anterior skull-base meningiomas found no significant differences in scores for all SF-36 domains between endonasal and supraorbital approaches.[45] In contrast, other findings on skull-base meningioma patients showed improved EQ-5D-3L scores at the one-year follow-up for non-frontotemporal surgical approaches.[39]

Radiotherapy was evaluated by eight studies,[16,18,23,25,27,38,40,43] of which five specified the type of radiotherapy administered (SRT,[18,25,40,43] fractionated radiotherapy,[18,27] intensity-modulated radiotherapy[43] or radiosurgery[43]). Overall, several studies revealed a consistent association with reduced HRQOL,[16,23,38,40,43] particularly in domains like vitality and physical role functioning as per SF-36 scores.[16,23,40] However, only one study[18] directly compared the different types of radiotherapy to discern their specific impacts on HRQOL. Notably, Fisher et al. found no significant differences observed between surgery-only and surgery plus adjuvant radiotherapy groups,[23] though another study found that adjuvant radiotherapy was linked with worse ASBQ pain scores.[38] Contrarily, Zamanipoor Najafabadi et al. observed no significant impact of any radiotherapy on SF-36 scores.[27] Both this study and

https://doi.org/10.1017/cjn.2024.273

Fisher et al. examined HRQOL at a median of nine years post-surgery but were not consistent in their evaluation of radiotherapy, which likely contributed to the observed discrepancies in the findings.[23,27]

Finally, the impact of **discharge destination** and **active surveillance** on HRQOL in meningioma patients was explored in only one study each.[17,24] Discharge home was associated with better long-term HRQOL on the general FACT and FACT-Br.[24] Patients under active MRI surveillance showed similar HRQOL scores compared to those receiving surgery or radiotherapy.[17]Additional research is needed to establish substantive conclusions regarding the influence of these factors.

Three of the seven studies[18,23,24,27,28,31,39] examining whether there was an association between the presence of **surgical complications** and HRQOL found a significant association. The presence of surgical complications was associated with lower HRQOL at one-year post-surgery in one study[39] and over five years post-surgery in another,[18] and intra- and postoperative bleeding, cerebrospinal fluid disturbances and cranial nerve disturbances were associated with worsened postoperative KPS scores in the third.[28]

Antiepileptic drug (AED) use was associated with lower HRQOL scores in two of three studies,[18,21,29] particularly in FACT-Br summary scores, SF-36 MCS and SF-36 domains of role-physical, social functioning, mental health, vitality and general health.[21,29] However, when executive functioning was controlled for, a significant association was only found in one of the eight domains on SF-36.[21]

HRQOL tools

A total of 11 unique tools were used to evaluate HRQOL in the included studies, with many studies using more than one (Table 5). The most common tools used were SF-36[46,47] ($N = 13$), followed by the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Brain Neoplasm 20 (EORTC QLQ-BN20)[48] ($N = 6$), European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Core 30 (EORTC QLQ-C30)[49] ($N = 6$), EQ-5D[50] ($N = 5$), KPS ($N = 5$) and FACT-Br[51] ($N = 3$). One article used a modified version of FACT-Br[25]. With the exception of KPS, which is a scale to measure functional status generally completed by the clinician, all tools are considered patient-reported outcome measures intended for completion by the patient themselves. Some studies have adopted KPS as a proxy of HRQOL, despite the fact that KPS may not encompass all aspects of HRQOL relevant to meningioma patients. The majority of these tools have undergone at least partial validation. However, only the FACT-Br tool has been validated in a diverse brain tumour population that includes meningioma patients.[51] Of the tools used, four measure generic HRQOL, while others are specific to certain conditions including brain neoplasms ($N = 2$), cancer ($N = 2$), sinonasal outcomes ($N = 1$) and anterior skull-base surgery ($N = 1$). Despite this variety, we emphasize that none of these tools were specifically designed and fully validated for exclusive use in meningioma patients.

Discussion

Summary of evidence

We found that HRQOL in meningioma patients is shaped by a complex array of treatment-related, clinical and sociodemographic variables (Figure 2). Our results, consistent with other reviews,[3,4,6,7] found that in general, meningioma patients appear to suffer from worse HRQOL outcomes compared to healthy controls. This is observed both before and after treatment, with the impact on HRQOL continuing for many years despite the overall beneficial effect of treatment. Nonetheless, it should be noted that significant heterogeneity was present in how studies measured HRQOL, and a standardized, validated tool for HRQOL evaluation in this specific population is not yet in use.

Patient-related factors

In terms of sociodemographic influences, age presents a multifaceted influence on HRQOL. The observation that younger patients endure reduced life satisfaction and protracted recovery phases in comparison to the older counterparts[25,36,42] can be partly explained by the fact that younger individuals frequently have greater life expectations and responsibilities, such as supporting dependents and managing financial obligations like home ownership. These factors intensify the stress of illness and can exacerbate the effects on HRQOL. Older adults may not experience the same level of impact, having already navigated these life stages. Unemployment is invariably associated with inferior HRQOL outcomes,[18,29,42] which could reflect both diminished functional status affecting employment and the potential financial strains impacting overall well-being, though the influence of income has not been well studied.

Our review highlights several other patient-related factors that have not been explored in detail by prior reviews. The effect of comorbidities on HRQOL[18,26–29] maybe due to the cumulative toll of managing both the tumour and the comorbidity. Furthermore, functional status and neurological function, both closely tied to the tumour's impact and the interventions received, stand out as likely predictors of HRQOL.[15,18,20–22,26,27,30,34] These factors involve aspects of daily living, cognitive abilities and motor functions, which may influence the patient's perceived HRQOL. Disturbances in sleep patterns, whether due to the tumour's presence itself or the psychological impact of having a serious diagnosis, may lead to a decline in HRQOL.[19,32,33] This requires further exploration, however, as various sleep assessment methods were employed. Finally, psychological impairments, ranging from anxiety and depression to PTSS, may have profound effects, not only as consequences of the disease process but also as predictors of how a patient perceives their recovery and overall well-being.[29,34,35]

Tumour-related factors

Previous literature suggests that patients with larger tumours or tumours situated in more critical or challenging brain regions may theoretically experience decreased HRQOL due to the complexities of surgical intervention, aggressive treatments and potential postoperative complications.[52,53] The findings presented here showing the minimal influence of tumour size[24,28,31,41,42] or location[18,27,28,30,34,41–43] on HRQOL and mixed histologic grade results[20,28,42] seem to deviate most significantly from these earlier reviews.

This discrepancy might stem from our included studies generally comparing broader tumour locations rather than specific localizations within meningioma subtypes. Furthermore, while many studies report a negative association between tumour size and neurological function, current generic HRQOL instruments may not be sensitive enough to detect specific neurological deficits, possibly underrepresenting the true impact of tumour size on HRQOL. Patients with tumours exhibiting unfavourable

https://doi.org/10.1017/cjn.2024.273

Table 5. Summary of quality of life (QOL) tools used in included articles (N = 31)

QOL tool	Type	Validated?	Domains	Description	Scoring system	N (%)*
ASBQ-35[37,38]	Anterior skull base surgery	Yes	Performance; physical function; vitality; pain; specific symptoms; emotions	35 items; 6 domains	5-point Likert scale. Total scores range from 35–175 points; higher scores indicate better quality of life	2 (6.5)
EORTC QLQ-BN20[17,18,23,32,42,43]	Brain tumour	Yes	Future uncertainty; visual disorder; motor dysfunction; communication deficit; headache; seizures; cognition; drowsiness; hair loss; itchy skin; weakness of legs; bladder control	20 items; 12 domains; intended to supplement the EORTC QLQ-C30	Domains scored on Likert scale (0–100); higher scores indicate either better functioning for the functional domains, or higher symptom burden for the symptom domains	6 (19.4)
EORTC QLQ-C30[18,19,32,41-43]	Cancer	Yes	Global health status; physical function; role function; cognitive function; emotional function; social function; fatigue; nausea/vomiting; pain, dyspnoea; insomnia; appetite loss; constipation; diarrhoea	30 items; 14 domains	Domains scored on Likert scale (0–100); higher scores indicate either better functioning for the functional domains, or higher symptom burden for the symptom domains	6 (19.4)
EQ-5D[20,22,31,34,39]	Generic	Yes	Mobility; self-care; usual activities; pain/discomfort; anxiety/depression	5 domains; self-rated health status using a vertical VAS	Domains scored on a 3–5 point Likert scale; VAS is scored from 0–100. The EQ-5D index value is calculated using a scoring system that assigns weights to different health states based on societal preferences, and ranges from −0.59 (representing the worst health state) to 1 (representing perfect health). A score of 0 indicates a health state equivalent to being dead	5 (16.1)
FACT-Br[24,29,35]	Brain tumour	Yes	Physical well-being; social well-being; emotional well-being; functional well-being; brain cancer-specific symptoms/concerns	44 items; 4 domains from FACT-G plus brain cancer-specific subscale	5-point Likert scale; higher scores indicate better functioning or well-being. The total sum of domain scores ranges from 0 to 200	3 (9.7)
FACT-G[24]	Cancer	Yes	Physical well-being; social well-being; emotional well-being; functional well-being	27 items; 4 domains	5-point Likert scale; higher scores indicate better functioning or well-being. The total sum of domain scores ranges from 0 to 108	1 (3.2)
KPS[28,30,43,44,52]	Generic	Yes	N/A	Scale to assess functional ability and overall performance in relation to disease; 11 categories; completed by clinician	Each category represents a specific level of functional status. It ranges from 0 to 100, with 0 being “dead” and 100 being “normal; no complaints; no evidence of disease”	5 (16.1)
Questions on Life Satisfaction Survey[36]	Generic	No	Health, income/financial security, leisure time/hobbies, physical condition/fitness, sexuality, friends/acquaintances, housing/living conditions, occupation/work, marriage, family life/children	Rates satisfaction with major domains of daily life and general satisfaction; 10 domains	Unknown**	1 (3.2)
SF-36[8,15-18,21,23,26,27,33,34,40,45]	Generic	Yes	Physical functioning, role limitations due to physical health problems, bodily pain, general health perception, vitality, social functioning, role limitations due to emotional problems, mental health	36 items; 8 domains	Domains scored on a Likert scale. The scores for each item are summed to obtain a total score (0–100); higher scores indicate better health or well-being	13 (41.9)
SNOT-22[37,38]	Sinonasal	Yes	Rhinologic, extranasal rhinologic, ear/facial symptoms, psychological, sleep dysfunction	22 items; 5 domains	5-point Likert scale. The scores for each item are summed to obtain a total score (0–110); higher scores indicate worse quality of life	2 (6.5)
Other***[25]	—	No	—	—	—	1 (3.2)

Notes: ASBQ-35 = Anterior Skull Base Questionnaire-35; EQ-5D = EuroQOL-5 Dimensions; EORTC QLQ-BN20 = European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Brain Neoplasm 20; EORTC QLQ-C30 = European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Core 30; FACT-Br = Functional Assessment of Cancer Therapy-Brain; FACT-G = Functional Assessment of Cancer Therapy-General; KPS = Karnofsky performance scale; SF-36 = 36-item Short Form Survey; SNOT-22 = Sinonasal Outcome Test 22; VAS = Visual Analogue Scale.

*Many studies used more than one tool

**Questionnaire published in German only

***Some included studies created a modified questionnaire based on existing tools, including FACT-Br (see Table 1)

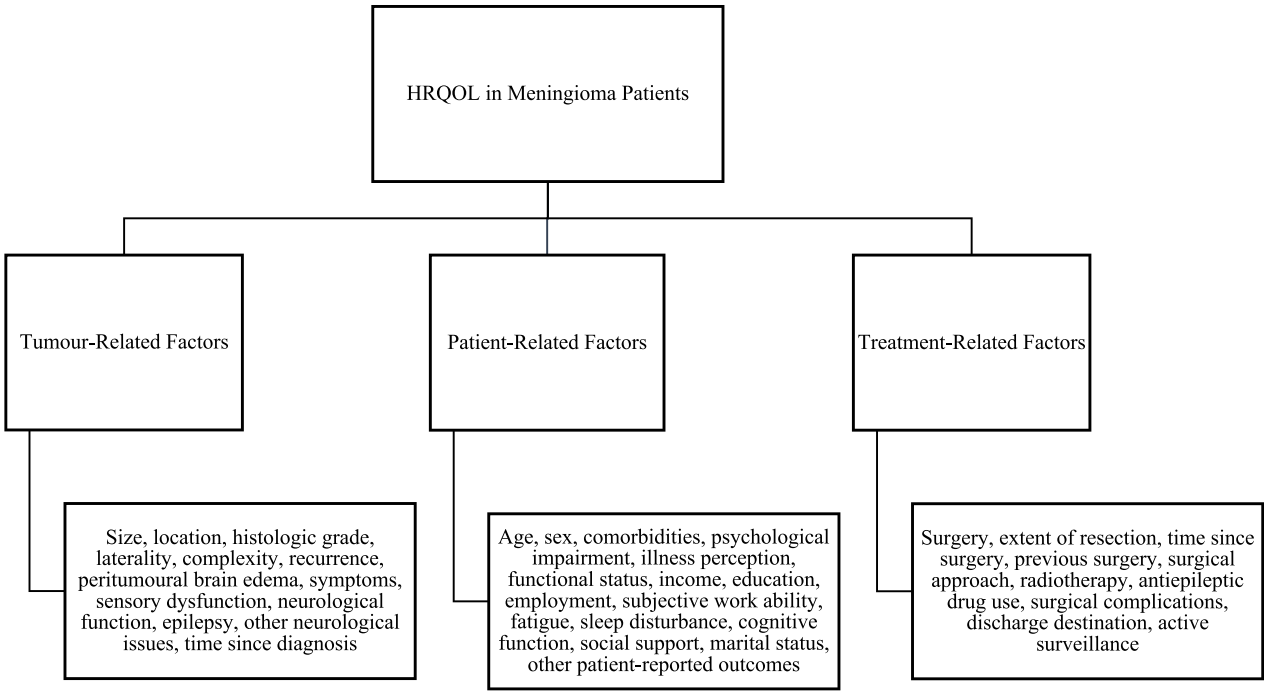

Figure 2. Health-related quality of life (HRQOL) factors explored by included studies (N = 31).

characteristics may also have lower HRQOL at baseline due to neurological and functional effects of the tumour, which can lead to a "floor effect" where subsequent declines are less detectable. This could partly explain the differences in findings, though more uniform evidence and homogenous reporting would facilitate a better understanding of the impact of tumour characteristics on HRQOL. Thus, while our findings suggest minimal effects, they may not reflect the entirety of the situation.

There is a need for targeted research to differentiate the impacts of AED use from the effects of epilepsy itself on HRQOL. While we observed that AED use appears to be independently correlated with poorer HRQOL, some earlier reviews used AED use as a proxy for epilepsy[8]. This approach may not adequately distinguish between the unique consequences of epilepsy and the side effects of its treatment on HRQOL. Understanding these separate influences is vital for improving treatment approaches, as both epilepsy and its management through AEDs can significantly affect patient outcomes. Further investigation in this area is essential for more nuanced and effective care strategies for meningioma patients.

Treatment-related factors

In line with previous reviews, surgical resection is a key treatment-related determinant of HRQOL.[4,6,7,9] As shown by many studies, the effects of surgery on HRQOL are particularly relevant immediately post-operation, but its effects lessen thereafter, with gradual improvement in domains such as headaches, seizures, and role limitations.[31,34,37,41,42]

The additional observation that patients having better preoperative HRQOL scores can face a postoperative decline[9,31] may be attributed to a "ceiling effect." Specifically, patients have minimal room for improvement if they are already scoring near the top of a scale, and the immediate challenges and recovery associated with surgery can provide room for temporary declines. The literature, however, has yet to thoroughly examine how varying surgical approaches specifically impact HRQOL outcomes.

The negative effect of resection extent, observed in one study, may be due to certain locations presenting greater challenges for resection, leading to less favourable HRQOL outcomes when total resection is attempted.[30] However, other factors, such as the absence of complications and preserved neurological function, may overshadow any negative effects of gross total resection on HRQOL. Ultimately, how the presence of the tumour or the side effects of its treatment impact neurological and functional status may be most significant for patients, as well as their ability to engage in everyday life. Future examinations of these possibilities are crucial to understand the holistic impact of meningioma treatment. This understanding can guide clinical decisions, ensuring that treatment strategies not only focus on maximizing tumour removal but also prioritize the overall HRQOL, functional independence and long-term well-being of patients.

Although it is suggested that surgical complications may have a negative impact on HRQOL,[18,28,39] inconsistencies in how these complications were defined across studies may have skewed the outcomes. Moreover, a comparative analysis of the impact of different complications on HRQOL is lacking. It is plausible that certain surgical complications might exert a more pronounced negative impact.[28] To gain a comprehensive understanding of these nuances, prospective research could aim to classify surgical complications by their degree of impact on HRQOL.

Radiotherapy serves multiple roles in the treatment of meningioma, often being the primary modality for patients with high surgical risks or tumours not amenable to resection. It is also frequently used adjunctively with surgery for residual or recurrent tumours. The context of its use is diverse, and each scenario presents different impacts on HRQOL, which have not been uniformly assessed. Further, most of the included studies did not evaluate the varied effects of different radiotherapy approaches.

https://doi.org/10.1017/cjn.2024.273

Patients receiving radiotherapy as initial treatment tended to experience reduced long-term HRQOL in specific domains[16,23,40,43] supporting previous reviews.[6,7] Observed less frequently, our review also supports a previous observation[8] whereby HRQOL diminishes post-treatment but returns to baseline or improves over the long-term follow-up.[40] Efforts should be made to examine whether this is an anomaly or if factors can be identified that contribute to this "bounce back" observation.

Our findings highlight that beyond the disease's impact, the HRQOL of patients with these tumours is significantly influenced by the available treatments, namely, surgery and radiation. However, comparing outcomes between surgery and radiation may not be entirely useful, as patients undergoing radiotherapy often have pre-existing compromised prognostic factors that may confound the results.[6]

Overall, this review brings to light several factors that may influence HRQOL in meningioma patients, especially patient-related elements such as age, employment status, comorbidities and psychological health. Treatment modalities like surgery and radiotherapy have been shown to have both immediate and long-term impacts on HRQOL. This comprehensive examination of existing evidence highlights the multifaceted and complex nature of HRQOL factors in meningioma patients.

Limitations of review

We acknowledge several limitations of this review that may influence the interpretation and generalizability of our findings. The majority of studies included were cross-sectional or retrospective with a small sample size and utilized normal population data with no control group to draw comparisons on HRQOL. The heterogeneity across the included studies posed a significant challenge. Variability in study design, setting, population, HRQOL assessment tools and effect measures used can complicate the synthesis of findings, making it challenging to directly compare and combine results and precluding the possibility of meta-analysis. There was also a prevalence of predominantly female populations in the included studies. While this reflects the demographic reality of meningioma patient cohorts, it potentially impacts generalizability. Finally, a frequent limitation was the possibility of inclusion bias, mainly due to high non-response rates. The HRQOL of those who declined study involvement may be different than those participating, potentially skewing the results.

Within the critical appraisal process, a lack of specific decision-making guidance provided by the JBI critical appraisal tools[11] for assessing the methodological quality is an important limitation. While these tools offer a structured approach to evaluating study quality, the reviewers were required to exercise judgement and adapt the tools to the specific research context, potentially introducing increased subjectivity into the quality assessment process.

However, to our knowledge, this is the first systematic review evaluating such a wide breadth of factors that may influence HRQOL in meningioma patients. The large number of studies meeting the eligibility criteria and their diversity, while making it difficult to synthesize quantitatively, ensures a broad representation of meningioma patients in areas of tumour location, histologic grade and phase of treatment, which in turn increases the generalizability of our findings. Further, our decision to conduct a narrative synthesis as opposed to alternative synthesis methods enabled a more nuanced understanding of the findings with consideration of patterns and relationships within the reviewed literature.

Gaps in literature and directions for future work

The current body of literature is predominantly composed of small-scale, single-centre studies, with a noticeable absence of prospective cohort studies and direct treatment comparisons. There is an emphasis on clinical outcomes such as tumour recurrence and survival, but HRQOL, an outcome of paramount importance to patients, remains underexplored. Adding to this deficit is the scarcity of research that encompasses caregivers' perspectives on their loved ones' HRQOL. Certain pivotal factors, like tumour location, histologic grade, epilepsy, surgical approach and social support, remain underrepresented. Current studies often aggregate tumour locations, diluting critical distinctions in how different locations may uniquely impact HRQOL. The lack of a standardized disease-specific HRQOL tool and reliance on generic HRQOL instruments may not sufficiently address the aspects of HRQOL important to meningioma patients, potentially limiting our understanding of the impact of a specific factor. Finally, the interplay between various factors influencing HRQOL in meningioma patients, including medical, psychological and sociodemographic variables, represents an inherent limitation in this field of study (Figure 3). This complexity introduces challenges in isolating the specific impact of individual factors.

These gaps highlight the urgency for robust, consistent research in large multi-centre samples that control for a variety of confounders in order to gain a holistic understanding of HRQOL determinants in meningioma patients. Future research should incorporate prospective, longitudinal studies that capture the trajectory of HRQOL post-treatment. Granular, location-specific studies are critical to explore the nuances of tumour site, treatment choices and their consequent impacts on HRQOL, aiding the complex decision-making process for treatments. Moreover, investigating caregiver experiences and other overlooked factors is essential to enrich our comprehension of HRQOL influences.

Previous work reveals multiple challenges for meningioma patients[54,55] in obtaining reliable and accessible resources, such as informational guidance, financial support, psychosocial aid and postoperative support. There is an absence of interventions that directly address the myriad HRQOL issues these patients face. Building on these insights, we recommend routine use of patient-reported HRQOL assessments, utilizing brain tumour-specific metrics like FACT-Br or EORTC QLQ-BN20 until a meningioma-specific validated tool becomes available.[55,56] Our research in this area aims to standardize such a measure for comparative future studies, improving our understanding of HRQOL in these patients.[57] The mixed impact of factors such as age and tumour size on HRQOL highlights the need for individualized treatment plans to address the varied HRQOL domains affected.[55] Given the significant heterogeneity and often limited subgroup representation in our review, we advocate for collaboration among specialized centres to consolidate HRQOL data. The generation of comprehensive datasets could inform the development of predictive algorithms for prognosticating outcomes and personalizing patient care, a practical and achievable goal within a healthcare system like Canada's.

https://doi.org/10.1017/cjn.2024.273

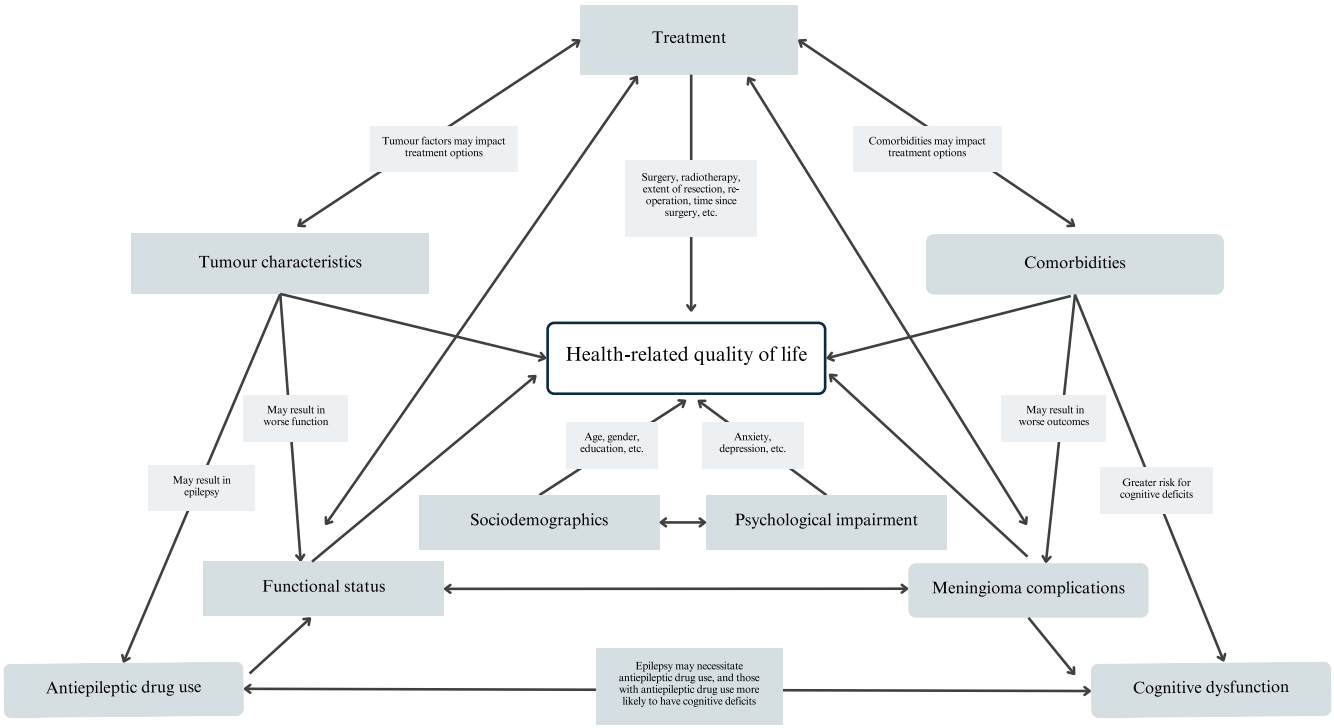

Figure 3. Schematic representation of how health-related quality of life factors may interact in meningioma patients.

Conclusion

Our systematic review of 31 studies indicates that treatment, neurological and functional status, comorbidities, sleep quality, psychological state, age and employment are key factors affecting HRQOL in meningioma patients. Study heterogeneity and inconsistent HRQOL measurements challenge conclusive findings. There is a need for more uniform, large-scale and prospective research with validated meningioma-specific HRQOL tools. Advancing this field requires routine HRQOL assessments and discussions about treatment implications on HRQOL, alongside individualized, multidisciplinary care and strong patient and caregiver support systems.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/cjn.2024.273.

Acknowledgements. We would like to acknowledge Julia Martyniuk, an Academic Librarian at the University of Toronto, for her contribution to this review by providing guidance on the development of the search strategy.

Author contributions. KJ: Study conception and design, conduction of literature search, eligibility screening, data extraction, data analysis and interpretation, manuscript preparation and critical revision.

MF: Study conception and design, eligibility screening, manuscript preparation and critical revision, provision of guidance and expertise.

MA: Data extraction, data analysis and interpretation, manuscript preparation and critical revision.

MDC: Study conception and design, manuscript preparation and revision, provision of guidance and expertise.

Funding statement. The authors received no funding for the development of this review.

Competing interests. The authors have no conflicts of interest to disclose.

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