

RESEARCH ARTICLE

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The Indonesian Version of the Neurological Assessment in Neuro-Oncology (NANO-Ina) Scale and Karnofsky Performance Scale (KPS) as Instruments for Assessing Postoperative Response in Meningioma and Its Influencing Factors

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Abstract

Objective: This study aimed to evaluate whether the NANO-Ina scale and the Karnofsky Performance Scale (KPS) can be used as instruments for assessing postoperative response in meningioma patients. **Methods:** This prospective cohort study was conducted among intracranial meningioma patients who underwent surgery at RSUPN Cipto Mangunkusumo and Dharmais Cancer Hospital from October 2024 to February 2025. Data collected included demographic, clinical, and tumor characteristics. The NANO-Ina scale and KPS were assessed before and after surgery. Statistical analysis included bivariate comparative tests followed by logistic regression and correlation tests. **Result:** A total of 52 subjects were included in this study, with a median age of 46 years (range: 33-61). The majority of subjects were female (90.4%), with the most common tumor location at the cranial base (69.2%), using perioperative steroids (75%), grade I histopathology (96.2%), and subtotal resection performed (73.1%). The mean NANO-Ina scores before and after surgery were 2.54 ± 2.35 and 2.15 ± 1.9 ($p=0.024$), respectively, while the KPS scores were 80.8 ± 12.2 and 82.9 ± 11.6 ($p=0.015$). There was a strong correlation between pre- and postoperative clinical performance, with NANO-Ina scale ($r=0.817$; $p<0.001$) and KPS ($r=0.831$; $p<0.001$). The only factor associated with postoperative NANO-Ina improvement was the preoperative NANO-Ina score. Factors associated with postoperative KPS included age, extent of tumor resection, and preoperative KPS. **Conclusion:** Preoperative NANO-Ina scale and KPS scores are associated with postoperative improvement, and a very strong correlation was observed between pre- and postoperative scores on both the NANO-Ina scale and KPS.

Keywords: intracranial meningioma, KPS, NANO scale, neurological conditions

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Introduction

Meningioma is the most common primary tumor of the central nervous system, accounting for approximately 24-37% of cases [1-3]. As an extra-axial intracranial lesion arising from the meninges, surgical resection remains the mainstay of treatment for symptomatic or progressive disease [4, 5]. Postoperative recurrence However, due to the cost and limited accessibility of MRI, regular neurological assessments during clinical visits may serve as a more practical alternative. Clinical deterioration identified through neurological examinations may facilitate timely decision-making for further treatment.

The Response Assessment in Neuro-Oncology criteria incorporate clinical performance, but they do not specify a standardized neurological examination for documenting

progression or recovery. Commonly used scales such as KPS and ECOG are simple and prognostically useful, yet they emphasize global function rather than specific neurological deficits [6-8]. The Neurologic Assessment in Neuro-Oncology scale was developed to address this limitation by evaluating nine neurological domains through direct observation and examination, allowing more objective clinical assessment in both trials and routine practice [9, 10].

The Indonesian version of the NANO scale (NANO-Ina) provides a culturally adapted instrument for neurological assessment. Angelita et al. demonstrated high validity and inter-rater reliability of NANO-Ina in Indonesian brain tumor patients [11]. Building on that work, the present study evaluated whether NANO-Ina and KPS can be used to assess postoperative response in

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meningioma and explored factors associated with early postoperative improvement.

Materials and Methods

This study employs a prospective cohort design with consecutive sampling. The study subjects are meningioma patients who underwent surgery at Cipto Mangunkusumo National General Hospital (RSUPN) and Dharmas Cancer Hospital between October 2024 and February 2025.

Inclusion and exclusion criteria

The inclusion criteria for this study are patients aged 18 years or older, with anatomical pathology results indicating meningioma (grades I, II, or III), and who are eligible for evaluation. The exclusion criteria include patients who received increased doses of steroids and anti-seizure medications (ASM) during the postoperative assessment, as well as those with comorbidities that could affect the evaluation results, such as stroke, metabolic encephalopathy, pneumonia, renal disorders, surgical complications, and others.

Procedure

At the first meeting (preoperative), patients underwent interviews and physical examinations to assess NANO-Ina and KPS scores. These assessments were performed by physicians who had received prior orientation and training in the use of both scales. Data were also collected from interviews and medical records, including age, sex, tumor location, tumor size, symptoms and clinical manifestations, comorbidities, extent of tumor resection, meningioma histopathological grade, and treatment during follow-up, including steroid and anti-seizure medication dosages. At the second meeting, conducted during the outpatient follow-up visit between postoperative day 10 and 1 month, patients underwent repeat interviews and physical examinations to reassess NANO-Ina and KPS scores.

The mean follow-up duration in this study was 20.1 ± 8.1 days, which was comparable to that reported in previous studies evaluating postoperative functional status and new neurological deficits, generally within 1–3 months after surgery. This follow-up window of 10–30 days was selected to capture early postoperative

clinical changes while minimizing potential confounding factors. By this time, surgical wound healing had generally progressed and dexamethasone dosage was more likely to have stabilized, allowing more reliable assessment using the NANO-Ina scale. In addition, follow-up was conducted at a minimum of 10 days after surgery to allow postoperative edema to subside and patients to resume functional activities. Andersen et al. reported that peritumoral edema in meningioma patients receiving corticosteroids decreased by approximately 50% within 7 days, supporting the timing of early clinical reassessment. Furthermore, Scheitzach et al. [12] showed that neurological deficits assessed at discharge using the MRC Neurological Performance Score remained stable at subsequent follow-up ($p=0.11$), suggesting that early postoperative evaluation may provide a representative measure of short-term clinical outcome.

Statistical analysis

Data analysis was conducted in four stages: descriptive analysis, correlation test, comparative, and multivariate analysis. All data were processed using SPSS version 29.

Results

Subject characteristics

A total of 52 subjects were included in this study. Table 1 presents the clinical and tumor characteristics of the subjects, with a median age of 46 years (range: 33–61). The majority of subjects were female (90.4%), with the most common symptoms being headache (80.8%) and visual disturbances (71.1%). The most frequently affected domain in the NANO-Ina assessment was visual field impairment (59.6%). Additionally, 50% of the subjects had comorbidities. Steroids were administered perioperatively in 75% of subjects, while only 19.2% received steroids during postoperative evaluation. Regarding tumor characteristics, most were located at the skull base (69.2%), were WHO grade 1 histopathologically (96.2%), and underwent subtotal resection (73.1%).

Comparison of NANO-Ina and KPS scores before and after surgery

Figure 1 illustrates the assessment of neurological deficits using the NANO-Ina scale and functional status

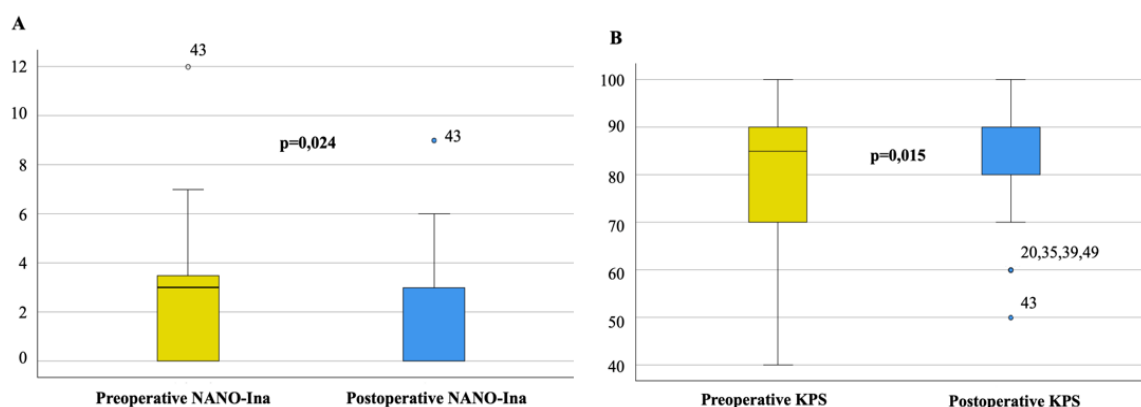


Figure 1. NANO-Ina (A) and KPS (B) Scores before (Yellow) and after Surgery (Blue)

Table 1. Clinical and Tumor Characteristics of Subjects (n=52)

Variable	n (%)
Sex	
Female	47 (90.4%)
Male	5 (9.6%)
Age (median (min-max)) years	46 (33-61)
Symptoms	
Headache	42 (80.8%)
Visual disturbance	37 (71.1%)
Seizures	12 (23.1%)
Other symptoms	18 (34.6%)
Asymptomatic	1 (1.9%)
Impaired domains (based on NANO-Ina scale)	
Gait	7 (13.5%)
Strength	6 (11.5%)
Ataxia (upper extremity)	2 (3.8%)
Sensation	5 (9.6%)
Visual fields	31 (59.6%)
Facial strength	6 (11.5%)
Language	4 (7.7%)
Level of consciousness	1 (1.9%)
Behavior	6 (11.5%)
Preoperative NANO-Ina score (mean±SD)	2.54±2.35
Preoperative KPS score (mean±SD)	80.8±12.2
Steroid use	
Perioperative steroid use	
Yes	39 (75%)
No	13 (25%)
Steroid use at postoperative assessment	
Yes	10 (19.2%)
No	42 (80.8%)
Comorbidities	
None	26 (50%)
Present	26 (50%)
Tumor characteristics	
Location	
Non-skull base	12 (23.1%)
Skull base	36 (69.2%)
Sphenoorbital	24 (46.1%)
Sella-suprasellar	5 (9.6%)
Olfactory groove	1 (1.9%)
Temporal based	3 (5.8%)
CPA	3 (5.8%)
Multiple	4 (7.7%)
Histopathology (WHO grade)	
I	50 (96.2%)
II/III	2 (3.8%)
Extent of tumor resection	
GTR	14 (26.9%)
STR	38 (73.1%)

Abbreviations: cerebellopontine-angle; GTR, gross total resection; KPS, Karnofsky performance scale; NANO, Neurologic Assessment in Neuro-Oncology; SD, standard deviation; STR, subtotal resection; WHO, World Health Organization

using the KPS conducted before and after surgery. The mean follow-up time for postoperative NANO-Ina and KPS evaluations was 20.1±8.1 days (calculated from the day of surgery). The mean NANO-Ina scores before and after surgery were 2.54±2.35 and 2.15±1.9, respectively, while the mean KPS scores before and after surgery were 80.8±12.2 and 82.9±11.6, respectively. Bivariate analysis showed a significant difference between pre- and postoperative NANO-Ina scores ($p = 0.024$) and between pre- and postoperative KPS scores ($p = 0.015$). These findings indicate a statistically significant difference in NANO-Ina and KPS scores before and after surgery. Spearman correlation analysis also significantly correlated with preoperative and postoperative clinical performance (NANO-Ina: $r=0.817$; $p<0.001$ and KPS: $r=0.831$; $p<0.001$).

The association of demographics, clinical, and tumor characteristics with postoperative improvement in NANO-Ina and KPS scores

Thirty percent of subjects showed improvement based on the NANO-Ina scale. Tables 2 and 3 present the factors associated with postoperative improvement in NANO-Ina and KPS scores and based on bivariate analysis for the dependent variable of postoperative NANO-Ina improvement, preoperative NANO-Ina and KPS scores significantly influenced improvement ($p<0.05$). For the bivariate analysis with postoperative KPS improvement as the dependent variable, the significant influencing factors were preoperative KPS and the extent of tumor resection.

Multivariate analysis of factors associated with improvement in postoperative NANO-Ina and KPS scores

Variables included in the logistic regression analysis were those with a p -value <0.25 based on the bivariate test. From the backward multivariate analysis, only the preoperative NANO-Ina score was found to be associated with improvement in the postoperative NANO-Ina score (Table 4). In contrast, factors influencing postoperative KPS included age, tumor resection, and preoperative KPS (Table 5). Based on the coefficient (B) values and adjusted odds ratios, better preoperative clinical performance tended to result in postoperative improvement. A lower NANO-Ina score was associated with postoperative improvement in the NANO-Ina score, while a higher preoperative KPS tended to lead to improvement in the postoperative KPS score.

Discussion

Mean NANO-Ina and KPS scores before and after surgery

In this cohort, both neurological impairment measured by NANO-Ina and functional performance measured by KPS improved significantly after surgery. The relatively favorable preoperative KPS in our cohort is consistent with reports showing that many meningioma patients present with preserved overall performance status because these tumors often grow slowly and follow an indolent clinical course [13-17].

Although the use of NANO in meningioma remains limited, our finding that 73% of patients had identifiable

Table 2. Association between Demographics, Clinical, and Tumor Characteristics and Postoperative NANO-Ina Scale (n=52)

Variable	Postoperative NANO-Ina Scale		OR (95% CI)	P value
	Improved (n=16)	Unchanged/ Worsened (n=36)		
Sex			0.255 (0.038-1.704)	0.163*
Female	13 (81.3%)	34 (94.4%)		
Male	3 (18.8%)	2 (5.6%)		
Age			0.455 (0.131-1.575)	0.209
≤45 years	5 (31.3%)	18 (50%)		
>45 years	11 (68.8%)	18 (50%)		
Preoperative NANO-Ina score				<0.001**
Preoperative KPS score				0.03**
Perioperative steroid use			3.08 (0.596-15.92)	0.298
Yes	14 (87.5%)	25 (69.4%)		
No	2 (12.5%)	11 (30.6%)		
Steroid use at postoperative assessment			2.818(0.683-11.632)	0.251
Yes	5 (31.3%)	5 (13.9%)		
No	11 (68.8%)	31 (86.1%)		
Comorbidities			0.325 (0.093-1.131)	0.071
None	5 (31.3%)	21 (58.3%)		
Present	11 (68.8%)	15 (41.7%)		
Location			Reference	0.695**
Non-skull base	5 (31.3%)	7 (19.4%)	2.143 (0.543-8.461)	
Skull base	9 (56.3%)	27 (75%)	0.714 (0.074-6.922)	
Multiple	2 (12.5%)	2 (5.6%)		
Histopathology (WHO grade)			N/A	0.09*
I	14 (87.5%)	36 (100%)		
II/III	2 (12.5%)	0 (0%)		
Extent of tumor resection			1.364 (0.372-4.997)	0.44*
GTR	5 (31.3%)	9 (25%)		
STR	11 (68.8%)	27 (75%)		

*Fisher's exact test; **Mann-Whitney test; Abbreviations: GTR, gross total resection; KPS, Karnofsky performance scale; NANO, Neurologic Assessment in Neuro-Oncology; N/A, not available; OR, odds ratio; STR, subtotal resection

neurological deficits before surgery is broadly consistent with previous studies reporting frequent focal deficits in meningioma patients [4, 14, 18]. The most commonly affected domain in the present cohort was visual field impairment, which is plausible given the high proportion of skull-base tumors.

Our results also support the responsiveness of both instruments to early postoperative change. Prior studies using KPS or other neurological severity scores have likewise demonstrated postoperative improvement after meningioma surgery [12, 16, 19]. Because NANO evaluates domain-specific neurological deficits, it may complement global functional measures such as KPS and provide additional clinical granularity [10, 20].

The strong correlation between preoperative and postoperative NANO-Ina and KPS scores indicates that baseline neurological and functional status remains an important determinant of early postoperative condition. Similar observations have been reported in glioma cohorts, where preoperative NANO and KPS were strongly associated with early postoperative outcomes [6, 8, 21].

Predictive factors

KPS remains a widely used prognostic scale in neuro-oncology, although reports on its value as a postoperative predictor in meningioma are not entirely consistent [22-25]. In the present study, higher preoperative KPS independently predicted postoperative KPS improvement, supporting the importance of baseline functional reserve in surgical recovery.

Lower preoperative NANO-Ina independently predicted improvement in postoperative NANO-Ina, suggesting that patients with better baseline neurological status are more likely to show favorable early postoperative neurological outcomes. Although meningioma-specific postoperative studies using NANO are scarce, prior work has suggested that lower NANO scores are associated with better treatment response in meningioma and glioblastoma [21, 26, 27].

Younger age and gross total resection were associated with better postoperative KPS improvement in our multivariate model. These findings are clinically relevant because they support the potential benefit of more

Table 3. Association between Demographics, Clinical, and Tumor Characteristics and Postoperative KPS (n=52)

Variable	Postoperative KPS		OR (95% CI)	P value
	Improved (n=14)	Unchanged/ Worsened (n=38)		
Sex			0.204 (0.03-1.379)	0.114*
Female	11 (78.63%)	36 (94.7%)		
Male	3 (21.4%)	2 (5.3%)		
Age			0.4 (0.107-1.501)	0.168
≤45 years	4 (28.6%)	19 (50%)		
>45 years	10 (71.6%)	19 (50%)		
Preoperative NANO-Ina score				0.063**
Preoperative KPS score				0.006**
Perioperative steroid use			0.776 (0.195-3.083)	0.729
Yes	10 (71.4%)	29 (76.3%)		
No	4 (28.6%)	9 (23.7%)		
Steroid use at postoperative assessment			1.208 (0.265-5.508)	0.807
Yes	3 (21.4%)	7 (18.4%)		
No	11 (78.6%)	31 (81.6%)		
Comorbidities			0.45 (0.127-1.596)	0.211
None	5 (35.7%)	21 (55.3%)		
Present	9 (64.3%)	17 (44.7%)		
Location			Reference	0.067**
Non-skull base	7 (50%)	5 (13.2%)	8.68 (1.963-38.374)	
Skull base	5 (35.7%)	31 (81.6%)	1.4 (0.144-13.568)	
Multiple	2 (14.3%)	2 (5.3%)		
Histopathology (WHO grade)			0.351 (0.02-6.031)	0.47*
I	13 (92.9%)	37 (97.4%)		
II/III	1 (7.1%)	1 (1.9%)		
Extent of tumor resection			4.429 (1.171-16.753)	0.03*
GTR	7 (50%)	7 (18.4%)		
STR	7 (50%)	31 (81.6%)		

*Fisher's exact test; **Mann-Whitney test; Abbreviations: GTR, gross total resection; KPS, Karnofsky performance scale; NANO, Neurologic Assessment in Neuro-Oncology; N/A, not available; OR, odds ratio; STR, subtotal resection

Table 4. Multivariate Analysis of Factors Associated with Postoperative NANO-Ina Scale Improvement

Variable	B	P value	Adjusted OR (95% CI)
Histopathology (WHO grade)			
I	-22.292	0.999	N/A
II/III			
Preoperative NANO-Ina scale (numeric)	-0.717	0.003	0,488 (0,306-0,778)
Constant	3.008	<0,001	

NANO, Neurologic Assessment in Neuro-Oncology; N/A, not available; OR, odds ratio

Table 5. Multivariate Analysis of Factors Associated with Postoperative KPS Improvement

Variable	B	p-value	Adjusted OR (95% CI)
Age			
≤45 years	-1.942	0.046	0,143 (0,021-0,97)
>45 years			
Preoperative KPS (numeric)	0.094	0.008	1,099 (1,024-1,179)
Extent of tumor resection			
GTR	2.75	0.006	15,649 (2,175-112,592)
STR			
Constant	-7.068	0.017	

GTR, gross total resection; KPS, Karnofsky performance scale; NANO, Neurologic Assessment in Neuro-Oncology; OR, odds ratio; STR, subtotal resection

aggressive resection when it is safe and feasible in fit patients, while also emphasizing the value of preoperative functional stratification during surgical planning [14, 16, 24, 28, 29].

Generalizability and clinical implications

The current study was conducted in two tertiary referral hospitals in Indonesia, and most tumors were WHO grade I and located at the skull base. These characteristics should be considered when interpreting external validity. Nevertheless, the core neurological domains assessed by NANO and the global function captured by KPS are not specific to Indonesia, so the present findings may be informative for other settings with similar case mixes. Additional multicenter studies from other countries and healthcare systems are still needed to confirm generalizability.

Early postoperative neurological deterioration occurred in 6.7% of our cohort, mainly in patients with complex skull-base lesions. This pattern is consistent with earlier reports identifying skull-base location, eloquent anatomy, vascular involvement, and technically demanding resections as important contributors to postoperative decline [18, 19, 30, 31, 32]. Together, these findings support routine preoperative NANO-Ina and KPS assessment as part of perioperative decision making and early postoperative follow-up.

Strengths and limitations

This study is the first to use the NANO-Ina scale, which was validated in Bahasa Indonesia in 2023. It is also the first Indonesian study to apply the NANO scale in meningioma. The study assessed the correlation of clinical performance pre- and post-surgery using NANO-Ina and KPS as standard instruments in oncological postoperative evaluation.

Several limitations should be considered. First, follow-up was limited to the early postoperative period (10-30 days, with a mean of approximately 20 days), so long-term neurological recovery, recurrence, and sustained functional change could not be assessed. Second, the sample size was modest (n=52), which may limit statistical power and generalizability. Third, tumor size and extent of peritumoral edema were not included in the multivariable analysis, so their independent effects on postoperative recovery could not be determined. Future studies with larger cohorts, longer follow-up, and more detailed imaging covariates are needed.

Author Contribution Statement

TA led the study including conceptualization, methodology, data curation, formal analysis, and drafting of the manuscript. MCA contributed to conceptualization, supervision, and critical revision. DT and RA contributed to data acquisition and manuscript revision. AR, AYS, and HRS provided supervision and critical review. IS contributed to project administration, investigation, and manuscript revision. All authors approved the final version of the manuscript.

Acknowledgements

Ethical declaration

This study was approved by the Ethics Committee of the Faculty of Medicine, Universitas Indonesia – Cipto Mangunkusumo National General Hospital (approval number: KET-1309/UN2.F1/ETIK/PPM.00.02/2024) and the Medical Research Ethics Committee of Dharmas Cancer Hospital (approval number: DP.04.03/11.10/03/2025). Written informed consent was obtained from all participants prior to inclusion. Patient confidentiality and data anonymity were strictly maintained throughout the study.

Data availability: (if apply to your research)

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of interest

Authors have no conflict of interest to declare.

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