

Surgical Outcome of Laminoplasty for Cervical Spondylotic Myelopathy in an Elderly Population – Potentiality for Effective Early Surgical Intervention: A Meta-analysis

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Abstract

A systematic review and meta-analysis was conducted to determine differences in surgical outcomes of laminoplasty for cervical spondylotic myelopathy (CSM) between elderly and non-elderly patients. PubMed and Google Scholar searches were performed using several key words and phrases related to cervical laminoplasty in elderly populations. Included studies were written in English, addressed laminoplasty for cervical spondylotic myelopathy, and evaluated outcomes of the treatment. Statistical analysis was performed using a random-effect model. The heterogeneity of the studies was assessed using Cochran's Q statistic and I² statistic, and a funnel plot was constructed to evaluate publication bias. The search initially identified 255 articles on this topic. Nine clinical studies that met all inclusion criteria were included in the meta-analysis. A total of 1817 patients in these studies underwent cervical laminoplasty. Elderly patients had lower preoperative and postoperative Japanese Orthopedic Association (JOA) scores, and lower recovery rates based on JOA scores. Shorter operation times and reductions in intraoperative blood loss were found in the elderly group compared to the non-elderly group. The incidence of C5 palsy was not different between these groups. We here report the differences in surgical outcomes of laminoplasty for CSM through systematic review and meta-analysis. This report found poor surgical outcomes and lower preoperative JOA scores in elderly patients. Therefore, early surgical intervention may be recommended in elderly patients with CSM.

Key words: outcomes, cervical spine, spondylotic myelopathy, meta-analysis, laminoplasty

Introduction

Cervical spondylotic myelopathy (CSM) is an age-related neurological disorder caused by narrowing of the cervical spinal canal as a result of degenerative intervertebral discs and adjacent vertebral structures. It causes functional disability due to gait disturbance and hand dysfunction with muscular atrophy and sensory disturbance; it is also the most common spinal disorder in elderly patients. Early surgical treatment can alter the natural history of CSM and improve prognosis in some patients.¹ Advanced age alone is not a contraindication to surgical treatment for CSM patients;² however, there is significant reluctance among surgeons to perform surgery in an elderly population because age is an independent factor that increases morbidity and is associated

with additional comorbid medical conditions.³ Cervical laminoplasty is a widely accepted treatment for patients with CSM, and numerous reports have documented satisfactory outcomes.^{4,5} However, surgical outcomes of laminoplasty in elderly patients with CSM are controversial. Several reports have indicated lower surgical outcomes in elderly patients,^{4,6–9} while other reports have described no significant differences in surgical outcomes between elderly and non-elderly patients.^{5,10,11} To date, no published reports have comprehensively evaluated surgical outcomes in elderly patients with CSM addressed by laminoplasty.

Therefore, we conducted a meta-analysis to review these data and to determine differences in surgical outcomes of laminoplasty for CSM between elderly and non-elderly patients, in order to provide guidance on the surgical strategy of cervical laminoplasty in these patients.

Materials and Methods

Sources

A systematic review was performed to identify the impact of age on the surgical results of laminoplasty in patients with CSM. PubMed databases were searched using the internet browser Safari version 9.1.3. Combinations of key words that describe age groups (“elderly,” “non-elderly,” “old,” “age”), disease of interest and management (“surgical outcome,” “surgery”), and surgical method (“laminoplasty”) and (“cervical spondylotic myelopathy”) were used to search for relevant articles. Full-text articles of all potentially appropriate studies were reviewed, and a manual search of the bibliographies of each retrieved article was conducted to identify publications not found in previous searches. Additional articles were located by cross-referencing articles encountered through Google Scholar searches. The date ranges of search articles spanned from 1988 to the present. Unpublished studies and abstracts were not included in this meta-analysis. No attempts were made to contact the authors of the included studies.

Study eligibility criteria

The inclusion criteria were as follows: 1) published in the English language; 2) a minimum of 40 patients per study and a report of appropriate outcome data of the cases; and 3) studies in which cervical laminoplasty was performed without fusion for CSM. We included prospective studies, retrospective studies, and case series. The exclusion criteria were as follows: 1) no specific population, exposure, and outcome; 2) nonscientific studies (such as commentaries and letters to the editor); and 3) review articles.

Study selection

Two reviewers (Y.T. and R.M.) screened the results independently after a calibration and training process. Disagreements between reviewers were resolved by discussion until a consensus was reached. Level 1 screening involved evaluating all available information returned by the electronic search. Level 2 screening involved evaluating full-text reports for studies deemed potentially eligible after Level 1 screening. Reviewers were not blinded during the search process. Appropriateness of the studies was determined from the aforementioned inclusion/exclusion criteria.

Statistical analysis

To analyze the efficacy of surgical outcomes, Japanese Orthopedic Association (JOA) score was used because of the most common scale for evaluation

of perioperative myelopathy condition. Therefore, The JOA score and recovery rate (%) were used to calculate mean differences (MDs) in both elderly and non-elderly groups utilizing Forest plots. The higher the JOA score, the better the functional status of the patient during the time of assessment. Some of these studies also attempted to use recovery rate (%) derived from the Hirabayashi formula:

$$\frac{(\text{postoperative JOA score} - \text{preoperative JOA score})}{17 - \text{preoperative JOA score}} \times 100\%$$

In our analysis, we estimated MD with a 95% confidence interval. Random-effects models were employed due to high heterogeneity of > 70% in most analyses. Odd ratios with 95% confidence intervals were also calculated for dichromatic parameters, which included complication rates. The inter-study risk of publication bias was also assessed using the funnel plot methodology. A *P* value of < 0.05 was considered statistically significant. All analyses were performed using Review Manager Version 5.0 (<http://ims.cochrane.org/revman/>).

Results

Search results

With compliance to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, we performed a PubMed database search to identify English-language literature published between 1998 and 2016. Our systematic review yielded a total of 255 papers on the initial search. After extensive screening, nine full-text articles that met previously described criteria were included. Of these, four were prospective trials^{2,9,13,14}) and five were retrospective^{8,10,11,15,16}) in terms of study design. A detailed flowchart of the search procedure is depicted in Fig. 1.

Baseline characteristic

The study characteristics of nine articles are summarized in Table 1. From these, 1817 patients underwent cervical laminoplasty, and 799 and 1018 patients were stratified to elderly and non-elderly groups, respectively. Two studies used 75 years old as the cut-off to define an elderly age, while the remaining studies used 65 or 70 years old as the minimum thresholds. The average age of the elderly group was 71.1 years, while that of the non-elderly group was 52.6 years. Forty-four percent of the patients were female in the elderly group, compared with 39.3% in the non-elderly group. The mean follow-up period was 37.8 months, except for one study in which it was not reported.

Clinical outcomes

Eight studies, with 742 elderly patients and 965 non-elderly patients, used the JOA score to evaluate functional status before and after surgery. The elderly group had lower preoperative JOA scores (Fig. 2A, MD -1.29 , 95% CI -1.56 to -1.02 ; $P < 0.00001$)

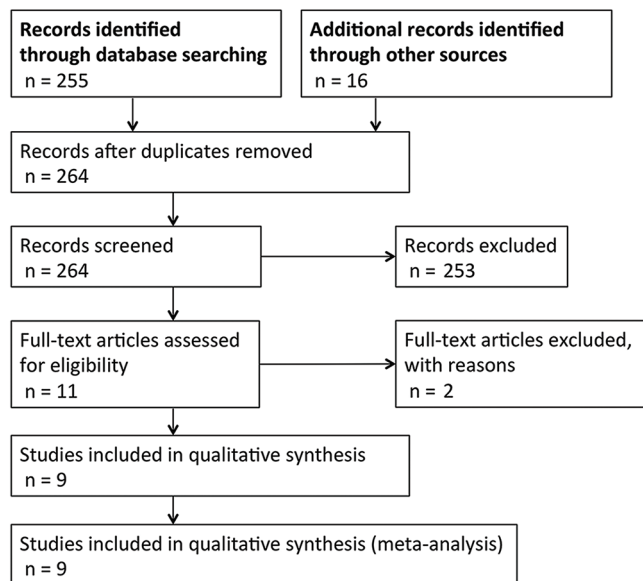


Fig. 1 Flowchart showing the meta-analysis of laminoplasty in CSM in elderly and non-elderly groups.

compared with the non-elderly group. In addition, the elderly group had lower postoperative JOA scores (Fig. 2B, MD -1.24 , 95% CI -1.48 to -1.00 ; $P < 0.00001$) and lower recovery rates (Fig. 2C, MD -10.54% , 95% CI -13.23% to -7.86% ; $P < 0.00001$). Publication biases were not significant in these parameters, by each survey using funnel plots. With regard to the timing of postoperative JOA score assessment, there are considerable variations between 12 to 40 months postoperatively among the literatures, and it was also unmentioned in some reports.

Intraoperative parameters

Five studies comprising 661 elderly patients and 884 non-elderly patients provided information regarding operative time. The non-elderly group had a statistically longer operation time (Fig. 3A, MD 8.98 min, 95% CI 5.67 to 12.29, $P < 0.00001$); however, there was significant heterogeneity between studies ($I^2 = 91\%$, $P < 0.00001$). Four studies comprising 585 elderly patients and 591 non-elderly patients provided information regarding intraoperative blood loss. The non-elderly group demonstrated significantly much intraoperative blood loss (Fig. 3B, MD 13.20 ml, 95% CI 5.73 to 20.68; $P = 0.0005$) compared with the elderly group.

Table 1 Baseline characteristics of studies included in the meta-analysis

Authors and year	Study design	No. of patients	Definition of age	Surgical methods	Mean follow-up period (months)
Machino et al., 2016	Prospective	505	Old-old ≤ 75 years ($n = 118$); young-old 65–75 years ($n = 186$); non-elderly < 65 years ($n = 201$)	Double door	26.5
Maeno et al., 2015	Prospective	100	Group 50s ($n = 21$); Group 60s ($n = 32$); Group 70s ($n = 37$); Group 80s ($n = 10$)	Single door	49.2
Son et al., 2014	Retrospective	62	Elderly ≤ 65 years ($n = 28$); non-elderly < 65 years ($n = 34$)	Single door	NR
Yoshida et al., 2013	Prospective	369	Elderly ≤ 75 years ($n = 76$); non-elderly < 75 years ($n = 293$)	NR	54.1
Machino et al., 2012	Prospective	520	Old-old ≤ 75 years ($n = 90$); young-old 65–75 years ($n = 143$); non-elderly < 65 years ($n = 287$)	Double door	33.3
Yamazaki et al., 2003	Retrospective	64	Elderly ≤ 65 years ($n = 35$); non-elderly < 65 years ($n = 29$)	NR	40.0
Kawaguchi et al., 2003	Retrospective	89	Elderly ≥ 70 years ($n = 20$); non-elderly < 69 years ($n = 69$)	Single door	78.7
Handa et al., 2002	Retrospective	61	Elderly ≥ 70 years ($n = 22$); non-elderly < 69 years ($n = 39$)	Single door	12.0
Tanaka et al., 1999	Retrospective	47	65–74 years ($n = 13$); 75–85 years ($n = 34$)	Double door	11.0

NR, not reported.

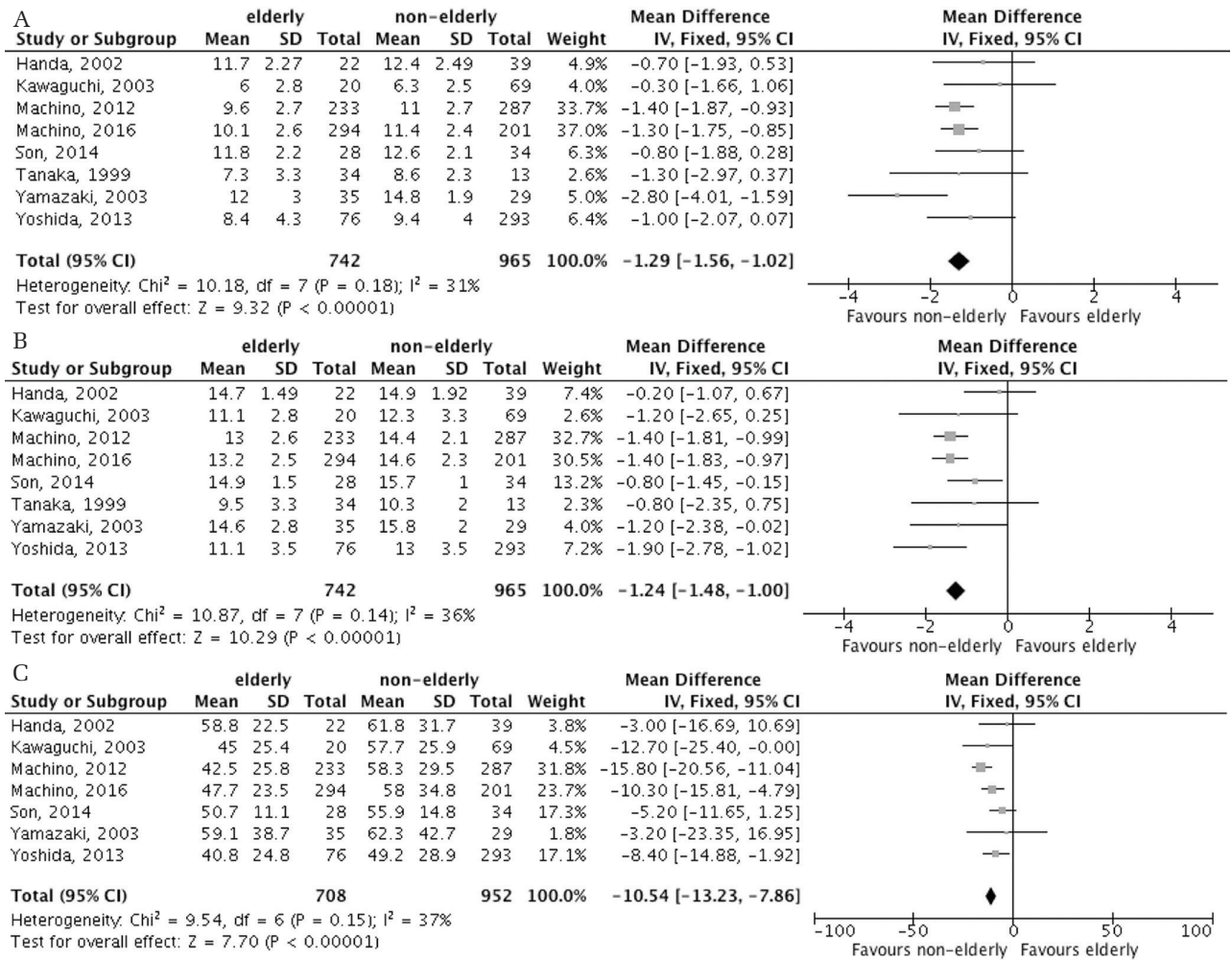


Fig. 2 Forest plots of patient clinical outcomes. A: Forest plot showing the mean difference in preoperative JOA scores between the elderly and non-elderly groups. B: Forest plot showing the mean difference in postoperative JOA scores between the elderly and non-elderly groups. C: Forest plot showing the mean difference in recovery rate (%) of JOA scores between the elderly and non-elderly groups.

Complications

C5 palsy is a commonly reported complication after cervical laminoplasty. The incidence of C5 palsy in three studies was evenly distributed among the elderly and non-elderly groups, with no evidence of statistical significance (Fig. 3C, OR 1.01%, CI 0.35–2.94, $P = 0.99$). In all 7 cases described by Machino et al.¹³, C5 palsy showed spontaneous recovery despite the classified groups. In the remaining 6 cases described in other literatures, it was not mentioned about postoperative C5 palsy if it shows spontaneous recovery or permanent disturbance.

Discussion

This meta-analysis revealed poorer surgical outcomes in elderly patients with CSM compared to non-elderly

patients. These patients had significantly lower preoperative and postoperative JOA scores, and lower recovery rates based on JOA scores; however, significantly shorter operation times and less intra-operative blood loss were observed in the elderly group. The incidence of C5 palsy was not different between these groups.

Poor surgical outcomes in elderly patients

There is consistent evidence that advancing age negatively affects outcomes in CSM.¹⁷ With regard to the outcome of cervical laminoplasty, several reports have previously described poorer outcomes in elderly patients compared to non-elderly patients,^{4,6-9} although other reports have suggested that there is no significant difference between these groups.^{5,10,11} Therefore, we conducted this meta-analysis to

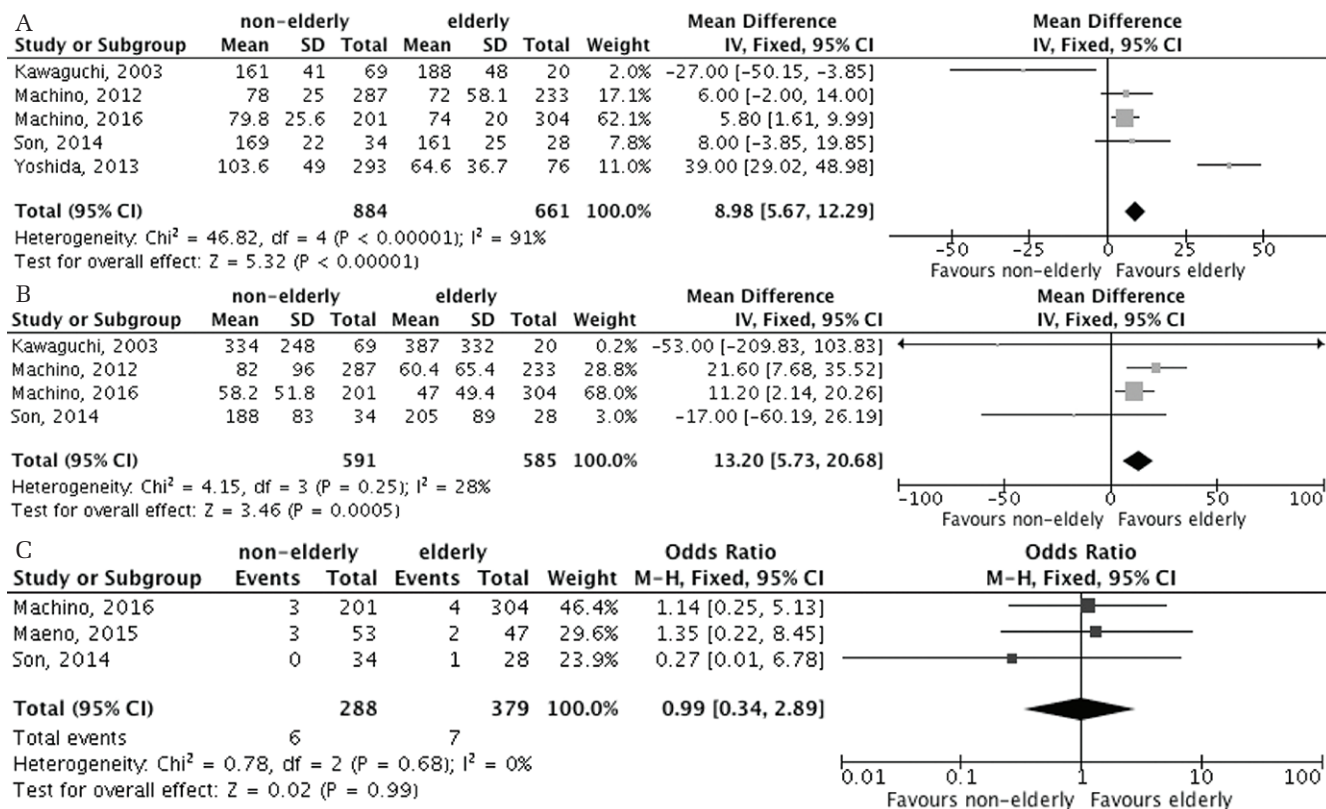


Fig. 3 Forest plots of patient intraoperative parameters and complications. A: Forest plot showing the mean difference in operation time (min) between the elderly and non-elderly groups; IV = inverse. B: Forest plot showing the mean difference in intraoperative blood loss (ml) between the elderly and non-elderly groups. C: Forest plot showing odds ratio of C5 palsy in the elderly group; M-H: Mantel-Haenszel.

comprehensively review these conflicting results. We found that elderly patients with CSM had poorer surgical outcomes of laminoplasty.

Elderly patients with CSM face significant challenges, as the progression of CSM to significant deterioration is rather quick in older patients.⁵⁾ Postoperative recovery in elderly patients is inferior to that in younger patients and represents a lack of restorative ability.^{4,8)} Some studies have also reported that longer symptom duration contributes to the poor surgical outcomes of laminoplasty, especially in elderly patients.^{1,5,16,18)} Furthermore, Jalai et al. recommended that elderly patients with CSM may have a lower risk of complications if intervention occurs sooner, based on a multicenter database review.³⁾ Therefore, early surgical intervention is recommended for elderly patients with CSM before progressive myelopathy develops.¹⁸⁾

Pitfalls in the use of JOA scores and recovery rates

The JOA scoring system has several pitfalls. In considering the functional status of the elderly population, it is important to note that lower JOA

scores are not solely reflective of myelopathy but also of other comorbid conditions such as hip and knee osteoarthritis, cerebrovascular disease, diabetic neuropathy, and prostate hypertrophy.²⁾ The recovery rate system of JOA scores also has some limitations. The most crucial scientific limitation is the fact that the actual surgical outcome in patients with the same recovery rate may differ according to the preoperative JOA scores;²⁾ in other words, lower preoperative JOA scores in elderly patients indicate lower recovery rate of JOA scores.

Additionally, the lower JOA recovery rate in the elderly population does not necessarily reflect negative postoperative outcomes. Some reports have demonstrated that the JOA recovery rate was lower in elderly patients than in non-elderly patients; the achieved JOA scores and SF-36 scale were not significantly different between the two groups,^{2,11,19)} indicating that elderly patients can still make significant gains in their quality of life. Therefore, laminoplasty for CSM may still be beneficial in elderly patients if preoperative JOA scores and the recovery rate are lower than those in the non-elderly group.

Reduced intraoperative blood loss and shorter operation times in the elderly group

Our analysis showed that there was reduced intraoperative blood loss and shorter operation times in the elderly group. Although significant recent advances in anesthesia have contributed to lesser morbidity in the elderly population,²⁰⁾ complications and mortality are increased among elderly CSM patients.³⁾ Therefore, the decision to perform surgery in elderly patients requires special consideration that is based on balancing the risks and benefits associated with surgery.²⁾ Smaller operative lesions would be selected as a result in elderly patients with CSM.²¹⁾ For these reasons, it is speculated that reduced intraoperative blood loss and shorter operation time may result from patients receiving smaller or less complex surgeries. But there were no any data about the difference of spinal levels decompressed with laminoplasty between two groups, further examinations will be needed to prove the speculation.

It is well-known that spinal degenerative changes progress with advancing aging and multilevel impairments occur in the elderly patients with CSM.²²⁾ If a minimally invasive method is selected in consideration of the higher perioperative complication risk in elderly patients, there is also a concern that smaller operative lesions may affect surgical outcome negatively. On the other hand, it is reported that the responsible spinal level can be located more cranially in elderly patients with CSM than in younger patients.²³⁾ Therefore, if surgical spinal levels are selected correctly through a close preoperative examination, smaller operative lesions may not affect the surgical results negatively in elderly patients.

Risk factor of C5 palsy after cervical laminoplasty

Postoperative paresis of the upper extremity following surgery for cervical lesions is a neurologic complication well known as C5 palsy. Several risk factors have been proposed, but there are few reports regarding age as a risk factor of C5 palsy. A recent meta-analysis evaluated the risk factors of C5 palsy following posterior cervical decompressing surgery.²⁴⁾ In the study, posterior spinal cord shifting, pre-existing intervertebral foraminal stenosis, ossification of posterior longitudinal ligament, laminectomy, and male gender were noted as risk factors; however, age was not listed as a risk factor. The incidence of C5 palsy was 4.3% and 3.1% in patients who underwent open-door and double-door laminoplasty, respectively. Our meta-analysis showed that the incidences of C5 palsy are 1.8% and 2.1% in elderly patient and non-elderly patients respectively, and that age is not a significant risk factor in C5 palsy.

Meta-analysis of surgical outcomes in elderly patients with CSM

In the literature review, there was one meta-analysis in which the surgical outcome for the elderly patients with CSM was already documented;²⁵⁾ however, it included variable surgical procedures including not only posterior decompression but anterior or posterior fusion methods as well. Variable methods indicate a large bias on each evaluated factor, which can introduce false conclusions. Additionally, the review included some errors in individual data. Therefore, we conducted another meta-analysis focused on patients treated by cervical laminoplasty alone.

Our findings showed lower preoperative JOA scores and recovery rates, which indicated poor surgical outcomes in elderly patients. However, the assessment of JOA scores or quality of life may also correctly evaluate surgical outcome; there are very few reports evaluating those with stratified ages. Therefore, further evaluations are necessary; in particular, the achieved JOA scores or the quality of life should be evaluated in a meta-analysis of surgical outcomes in elderly patients with CSM.

There are some reports indicating that the preoperative JOA score of the patients with CSM is significantly associated with postoperative outcome.²⁶⁾ It is also well-known that the earlier surgical intervention gets the better outcome in these patients.²⁶⁾ Therefore, there is a possibility that early surgical intervention would improve postoperative outcome in the elderly patients with CSM who had lower preoperative JOA score. However, there is no report about the predicting value of the preoperative JOA score evaluated separately by age. So further research should be conducted to compare the predicting value of the preoperative JOA score between different age groups.

Limitations

There are several limitations in this study. Our meta-analysis includes many retrospective analyses. The patients included in this report did not closely group into elderly and non-elderly groups, because accepted thresholds are different among literatures.³⁾ The surgical method selected was a single procedure as cervical laminoplasty but different types of laminoplasty, such as double-door or single-door methods, were also conducted in the included reports. In addition, the surgical indications might differ across these studies. Moreover, the timing of surgery or duration of symptoms was not addressed due to insufficient data. Because the clinical outcome was evaluated only by a single scale of JOA score, the evaluation in this meta-analysis may be biased.

Conclusion

We determined differences in surgical outcomes of laminoplasty for CSM between elderly and non-elderly patients through a systematic review and meta-analysis. Because the results of this study showed poor surgical outcomes with the lower preoperative JOA scores in elderly patients with CSM, early surgical intervention may be recommended for elderly patients. For additional assessment of effectiveness in surgical treatment, another systematic review closely focused on the postoperative quality of life in elderly patients should be conducted in the future.

Conflicts of Interest Disclosure

The authors report no conflicts of interest concerning the materials or methods used in this study or the findings specified in this paper.

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