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REVIEW ARTICLE

Axial pain after posterior cervical spine surgery: a systematic review

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Abstract Posterior operative approach has been the standard treatment for cervical compressive myelopathy, and axial pain after laminoplasty or laminectomy as a postoperative complication is now gradually receiving more and more attention. The objective of this study was to provide a systematic review of the current understanding of axial pain after cervical laminoplasty and laminectomy, and summarize clinical features, influence factors and preventive measures of axial pain after posterior decompressive surgery based on a review of literature published in the English language. Axial pain distributes over nuchal, periscapular and shoulder regions. Posterior surgery is not the major cause of axial pain, but axial pain can be worsened by the procedure. There are many clinical factors that influence postoperative axial pain such as age, preoperative axial pain, different surgical technique and postoperative management, but most of them are still controversial. Several surgical modifications have been innovated to reduce axial pain. Less invasive surgery, reconstruction of the extensor musculature, avoiding detachment of the semispinalis cervicis muscle and early removal of external immobilization have proved to be effective. Axial pain is under the influence of multiple factors, so comprehensive methods are required to reduce and avoid the postoperative axial pain. Because of methodological shortcomings in publications included in this systematic review, different results from different studies may be produced due to differences in study design, evaluation criteria, sample size, and incidence or severity of axial pain. More high-quality studies are necessary for drawing more reliable and convincing conclusions.

Keywords Axial pain · Laminoplasty · Laminectomy · Cervical spine · Systematic review

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Introduction

As a well-established procedure, posterior decompressive surgery with laminectomy or laminoplasty has been used widely for the treatment of cervical myelopathy caused by multilevel spondylosis and/or developmental spinal stenosis, or ossification of the posterior longitudinal ligament. The advantages of posterior approach include indirect decompression without destabilizing the disc space, intuitive operation while exposing multiple levels, and less risk of postoperative instability and adjacent level degeneration compared with the anterior approach. As the adverse outcomes after laminectomy, such as segmental instability, kyphotic deformity, perineural adhesions and late neurologic deterioration, are recognized [3, 27, 28], various forms of laminoplasty have been developed to avoid these complications. Studies have reported that the surgical outcomes of laminoplasty are more satisfactory [1, 18, 21, 45], but postoperative problems, such as axial pain, C5 palsy, restriction of neck motion and loss of lordotic curvature, are also noted [10, 11, 15, 18–20, 27, 35].

Since first described in 1996 [10], axial pain has been defined as pain from the nuchal to the periscapular or shoulder region [1, 2, 16, 22, 30, 38]. Such a complication has been reported mainly after posterior cervical surgery, but has been documented also in the anterior procedure. Although axial pain after posterior cervical surgery has been the focus of some studies, the results are often inconclusive and even conflicting. Here, we provide a systematic review of the current literature and attempt to analyze the conflicting results among studies, to better understand clinical features, influence factors and preventive measures of axial pain after posterior cervical surgery with laminectomy or laminoplasty. To our knowledge, this is the first systematic review of literature on this subject.

Materials and methods

A literature search was conducted on PubMed (http://www.ncbi.nlm.nih.gov/pubmed/) database using the keywords "axial pain", "neck pain", "axial symptoms", "laminectomy" and "laminoplasty" with the limitations of human subjects and English language. Additional articles found by manual methods from the references of the identified literature that contained relevant supporting information were also included. The search was performed by two dependent reviewers.

After excluding identical papers, we set out to select peer-reviewed articles for inclusion. The selected articles met the following criteria:

- literature published between 1996 and July 2009;
- studies that consisted of ten or more cases and focused on axial pain by statistical analysis;
- articles referring to posterior approach or both posterior and anterior approach.

A publication was excluded from the systematic review if it had any of the following criteria:

- studies without a clear description and analysis of axial pain;
- literature pertaining only to the anterior approach;
- articles with duplicate information. If the articles were reported by the same authors from the same institute, the most recently reported paper with detailed and complete clinical data would be included. If an equal number of patients were reported by the same authors, the articles with the most information were selected.

The information extraction of articles was done independently to minimize selection bias and errors. All abstracts that met our search terms were printed and thoroughly studied by two experienced spine surgeons. The different information extracted from the same article was compared and discussed. Discrepancies were resolved by a third reviewer, where necessary. Finally, a total of 33 papers were included for review. The full text of each paper was found, and then careful reading and data extraction were done independently by the two surgeons mentioned above. All extracted information was imported into an electronic spreadsheet—Microsoft Excel. A meta-analysis was not conducted because very few studies specialized in axial pain were found, and there was too much clinical heterogeneity among studies. Instead, we chose to provide a qualitative descriptive analysis.

Results

The search generated 184 hits. After screening titles and abstracts, 131 studies were excluded. Of the remaining 53 studies, 33 publications were included after reading the full text of articles according to the inclusion criteria. We found a total of 26 studies that referred to incidence, region or level of axial pain [1, 2, 6–11, 14–16, 19–22, 25–31, 35, 36, 42, 45, 47, 48]. Thirteen studies that statistically evaluated the correlation between clinical factors and axial pain are summarized in Table 1. Thirteen studies that compared two posterior surgical approaches on axial pain are shown in Table 2.

Clinical features

A total of 26 studies rendered 1297 cases with the number of patients enrolled ranging from 13 to 173 in each study and the mean age of 51.1–69.7 years at the time of surgery. The incidence of postoperative axial pain varied markedly with the range from 5.2 to 61.5%. The range of follow-up was approximately 1–10 years. Pain distribution included nuchal, periscapular and shoulder regions, and the nuchal region was the predominant region. The severity of axial pain was increased in the sitting or standing position and decreased in the supine position. Downward displacement of the upper extremities may induce axial pain in the sitting position [7]. Most of the patients experienced neck and shoulder pain in the early postoperative stages, and then these symptoms subsided gradually [10, 22, 42, 48]. However, intractable axial pain might persist for more than 10 years after surgery [35], and often influences patients' quality of life [1, 2, 15, 16, 36, 47].

The methods employed to evaluate the intensity of axial pain included visual analog scale (VAS), numerical rating scale (NRS) and Robinson scale. Some authors [19, 30, 42] also utilized the questionnaires to analyze the severity of axial pain. Time-related change of the degree of axial pain was characterized by gradual decrease in VAS after surgery [42, 47]. The patients often did not need analgesics to relieve postoperative axial pain [1, 2, 47], but researchers of two studies [10, 25] observed that a few patients (8–13%) needed mild analgesics due to axial pain.

The incidence of newly developed, worsened or improved pain after surgery was reported in two studies

Table 1 Summary of clinical studies on statistic evaluation of the correlation between clinical factors and axial pain after laminoplasty

References	Clinical factors	Correlation description	Statistic analysis
Higashino et al. [6]	JOA recovery rate, C2–7 Cobb angle, ROM	Relationship between the recovery rate of the JOA score; the C2–7 angle, the ROM and AP was NS	NA
Hosono et al. [10]	The facet joint resection ratio	The average resection ratio between the groups with or without AP was NS	NA
Hyun et al. [11]	Postoperative ROM, interval changes in ROM	Relationship between AP NRS scores and ROM or interval changes in ROM was NS	Spearman rank correlation coefficients
Kang et al. [15]	ROM	Relationship between postoperative ROM and postoperative AP was NS	Pearson correlation coefficient test
Kato et al. [16]	Age (>63 years), preservation of muscles attached at C2 or C7, female, types of disease (CSM/OPLL), duration of symptoms, change of alignment, change of ROM, preoperative JOA and recovery rate, operation time and blood loss	Older age and preservation of paraspinal muscles attached at C2 each significantly decreased the risk of postoperative AP. But other factors were each unrelated to AP	Multivariate logistic regression analysis
Kawaguchi et al. [19]	Age, gender, types of disease (CSM/OPLL), pre- or postoperative JOA scores, operation time, and blood loss, number of bone graft, CPK activity, chin–chest distance, rotational neck ROM, number of fused laminae, neck ROM, open-door side or either hinge side	Operation time, chin–chest distance, the number of fused laminae between severe AS group and mild group was significantly different But other factors were NS between the two groups. The AS area was not related to the open side or either hinge side	t test with Welch's correction
Kawakami et al. [20]	Preoperative instability, ROM	The prevalence of AS between patients with and without preoperative instability was NS Relationship between postoperative ROM and postoperative AP was NS	χ^2 analysis and Student's t test
Matsumoto et al. [26]	Lamina closure	AP score between the groups with or without lamina closure was NS	Unpaired t test
Nakama et al. [29]	IR in muscle strength, IR = post/pre	In men, the correlation between the IR in muscle strength and alleviation of the AP was strongly negative for extension and flexion. In women, the correlation was significant only for extensor strength	Spearman rank correlation coefficient
Ohnari et al. [30]	Age, sex, surgery time, duration of cervical orthosis, blood loss, reconstructive surgery of SSC muscle, preoperative AP	All the factors between postoperative AP group and no AP group was NS	Fisher exact test and Mann–Whitney U test
Okada et al. [31]	C2–7 Cobb angle	Relationship between positive change of Cobb angle and improvement in AP was minimally significant	Pearson correlation coefficient test
Sasai et al. [37]	The number of EBLP	The postoperative AS score significantly correlated with the numbers of EBLPs	Spearman rank correlation analysis

Table 1 continued

References	Clinical factors	Correlation description	Statistic analysis
Yoshida et al. [47]	Age, pre- or postoperative JOA scores, preoperative AP, A–P canal diameter, JOA recovery rate, cervical disease (CSM/CDH/OPLL), cervical alignment	The recovery rate score between the worse than moderate AP and less than mild AP showed significant difference But the age, A–P canal diameter, pre- or postoperative JOA scores between the two groups was NS. Relation between AP and cervical disease or cervical alignment was NS. The incidence of postoperative AP was significantly higher in patients beyond 70 years of age and who had preoperative AP	Student's *t* test with Welch's correction

NA not available, *AP* axial pain, *AS* axial symptoms, *NS* not significant, *CDH* cervical disc herniation, *ROM* range of motion, *IR* improvement ratio, *EBLP* en bloc laminoplasty

[16, 47]. Only one study [29] reported that the incidence of axial pain in women was twice as much as in men. The incidence of postoperative axial pain was reported to increase in three studies [16, 30, 47] and to decline in three [2, 20, 21], respectively, as compared to preoperatively. One study [31] showed postoperative aggravation of axial pain, whereas five [1, 2, 11, 25, 42] reported pain alleviation. Three studies [7, 9, 36] focused on early axial pain and late axial pain after surgery found that the frequencies of early axial pain were higher than late axial pain.

Influencing factors

Age

The mean age at the time of surgery was 51.1–69.7 years. Of 26 studies, 5 utilized age as the influencing factor. Three studies [19, 30, 47] found no significant difference in age between mild and severe axial pain group, or between axial pain and no axial pain group. One study [16] found that older age (>63 years) significantly decreased the risk of postoperative axial pain (Table 1). Another study [47], on the contrary, showed that axial pain was significantly higher in patients older than 70 years of age. None of these studies further analyzed the relationship between this potential factor and axial pain.

Sex

A male preponderance was evident in most studies with the ratio of man to woman of approximately 1.2:1. Three papers referred to sex as influence factor in their studies [16, 19, 30]. No correlation was found between gender distribution of patients and axial pain after surgery in these studies (Table 1).

Types of disease

Three studies [16, 19, 47] confirmed no relationship between postoperative axial pain and types of cervical disease including cervical spondylosis, OPLL and multi-level cervical disc herniation after cervical laminoplasty (Table 1).

Duration of symptoms

The duration of axial pain ranged from 6 months to 10 years. The relationship between preoperative duration and the occurrence of postoperative axial pain was not mentioned in all studies except one [16], in which duration of symptoms (>10 months) was not shown to increase the risk of axial pain after laminoplasty (Table 1).

Table 2 Summary of results on the statistic evaluation of modified and conventional posterior approach on axial pain

References	Surgical approach	Operation time	Blood loss	Orthotic use	Neck exercise	Neurological evaluation	Radiological assessment	Posterior muscles atrophy	Others	AP/index
Hosono et al. [7]	A = C3–6 ODLP B = C3–7 ODLP	Yes	No	Yes/2 w	NA	NA	No	NA	NA	Yes/ incidence
Kaminsky et al. [14]	A = ODLP B = laminectomy	NA	NA	No/4–8 w	NA	Yes/Nurick score	Yes/ROM	NA	NA	Yes/VAS
Kawaguchi et al. [17]	A = modified C3–7 ODLP B = C3–7 ODLP	Yes	No	Yes/1,3 mos	Yes	No/JOA No/recovery rate	Yes/ROM	NA	Yes/number of fused laminae	Yes/ incidence
Kotani et al. [22]	A = ODLP using a deep extensor muscle preserving approach B = ODLP	NA	NA	No external supports	No/3 d after surgery	No/JOA No/recovery rate	No	Yes	NA	Yes/VAS
Kowatari et al. [23]	A = C4–6 FDLP with C3 laminectomy B = C4–7 FDLP with C3 laminectomy	NA	NA	Yes/2–3 w	NA	No/JOA No/recovery rate	No	No	NA	No/incidence, intensity, severity
Okada et al. [31]	A = FDLP B = ODLP	Yes	Yes	NA	NA	No/JOA No/recovery rate	Yes/change in Cobb angle	NA	NA	Yes/VAS
Otani et al. [33]	A = segmental partial laminectomy B = ODLP	NA	NA	No/2 mos	NA	No/JOA No/recovery rate	Yes/change in ROM	NA	NA	No/incidence
Sakaura et al. [36]	A = modified C3–6 ODLP [5] preserving nuchal ligament attached to the C7 B = C7 and C6	NA	NA	No/2 w	NA	NA	Yes/C6–7 level	NA	NA	No/incidence
Shiraishi et al. [39]	A = skip laminectomy B = C3–7 ODLP	No	No	Yes/0, 4–8 w	NA	No/recovery rate	Yes/ROM	Yes	NA	Yes/ incidence
Takeuchi et al. [41]	A = C4–7 FDLP with C3 laminectomy B = C3–7 FDLP	NA	NA	No/1–2 w	No/start at 1–2 w	NA	NA	Yes	NA	Yes/severity
Takeuchi et al. [42]	A = C3–6 FDLP B = C3–7 FDLP	NA	NA	No external supports	No/few days after surgery	No/JOA No/recovery rate	NA	NA	NA	Yes/VAS
Tsuji et al. [44]	A = selective ODLP B = C3–7 ODLP	NA	NA	No/3 w	No	No/recovery rate	No	NA	NA	Yes/severity
Yukawa et al. [48]	A = skip laminectomy B = C3–7 FDLP	No	No	No/13 d, 14 d	NA	No/JOA No/recovery rate	No	NA	NA	No/VAS

Yes significance between group A and B, *no* no significance between group A and B, *NA* not available, *AP* axial pain, *ODLP* open-door laminoplasty, *FDLP* French-door laminoplasty, *mos* months, *w* weeks, *d* days

Preoperative axial pain

There were two studies [30, 47] with regard to preoperative axial pain (Table 1). One study [47] found that approximately 40% of the patients experienced axial pain after surgery, but it occurred primarily in patients who had the pain before surgery and continued to have them after surgery. In another study [30], however, no significant difference in preoperative axial pain was noted between patients with axial pain and no axial pain.

Surgical technique

Five studies [10, 16, 19, 30, 37] involved surgical factors in laminoplasty such as the number of bone grafts in the open gap (fusion of laminae), preservation of muscles attached at C2 or C7, reconstruction of the semispinalis cervical muscle insertion at the C2 spinous process, number of en bloc laminoplasty and facetectomy (Table 1). The results showed that preservation of muscles attached at C2 in the selective laminoplasty significantly decreased the risk of postoperative axial pain [16]. Another study [37] showed that the number of opened lamina significantly correlated with postoperative axial pain and that patients who received en bloc laminoplasty of two adjacent lamina did not present with axial pain at all. No significant difference between axial pain and factors regarding surgical technique for laminoplasty was noted in the other studies.

One study [19] demonstrated that the area of axial pain was not related to either the open side or hinge side in the open-door laminoplasty. Thirteen studies compared surgical approaches to determine which approach would significantly reduce the incidence or severity of axial pain (Table 2). The results of 8 of these 13 studies [7, 17, 22, 31, 40–42, 44] suggested that modified laminoplasty produced less axial pain than conventional laminoplasty. Modified laminoplasty included less invasive surgery and reconstructive technique. Only one study [14] compared the postoperative axial pain between laminectomy and laminoplasty approaches, indicating that laminoplasty was associated with less late axial pain. Other surgical techniques such as reconstruction of the spinous process–ligament–muscle complex [24], threadwire T-saw laminoplasty [2], en bloc laminoplasty without dissection of paraspinal muscles [8] and expansive laminoplasty with various kinds of spacers [43] were beneficial in reducing the incidence of axial pain. These studies, however, had no control groups and/or no validated measures of assessment of axial pain.

Three studies [16, 19, 30] confirmed no relationship between postoperative axial pain and operation time or blood loss (Table 1), although operation time or blood loss was usually believed to be related with soft tissue damage and therefore induced axial pain.

Postoperative management

The duration of cervical orthosis ranged from 0 to 3 months. Most of the patients (71%) received cervical collar for 2–3 weeks after laminoplasty. Only one study [30] with regard to the duration of cervical orthosis after cervical laminoplasty showed no difference between the axial pain and no axial pain group (Table 1). The duration of external immobilization, which may be related to postoperative axial pain, was significantly recorded in 3 of 12 comparative studies [17, 23, 40] (Table 2).

Neurological evaluation

The Japanese Orthopedic Association (JOA) score and Nurick scale system were used in these studies. The authors of four studies [6, 16, 19, 47] discussed the relationship between axial pain and pre- or postoperative JOA scores or JOA recovery rate. Only one study [47] demonstrated that the JOA recovery rate was significantly different between the worse and moderate axial pain group and less than mild axial pain group (Table 1). No correlation between axial pain and neurological function was found in the remaining three studies.

Radiological assessment

Radiological examination included plain radiography, computed tomography (CT) and magnetic resonance imaging (MRI). The measurement parameters were defined as cervical alignment (C2–7 Cobb angle), flexion–extension neck range of motion (ROM), anteroposterior diameter of the spinal canal (A–P canal diameter), preoperative instability, lamina closure and number of fused levels (Table 1). There were eight studies with the data on postoperative cervical alignment [6, 31, 47], changes in alignment [16], postoperative ROM [6, 11, 15, 19, 20] and changes in ROM [11, 16]. The results showed that these factors were not correlated with postoperative axial pain in all these studies except one [31], in which minimal correlation between positive change of Cobb angle and improvement in axial pain was found. There were no significant differences between postoperative axial pain and A–P canal diameter [47], preoperative instability [20] or lamina closure [26], but the number of fused laminae [19] was significantly related to postoperative axial pain. Three of 12 comparative studies [22, 40, 41] showed the correspondence between atrophy rate and incidence or severity of axial pain (Table 2), suggesting that posterior muscle atrophy may be related to postoperative axial pain.

Others

Other clinical factors including improvement ratio (IR) in muscle strength [29], chin–chest distance [19] or both were related to postoperative axial pain (Table 1). The results showed that extensor/flexor muscle strength ratio was significantly higher in the axial pain group 1 year after surgery than no axial pain group, indicating that neck pain was derived from an imbalance of the two muscle strengths.

Discussion

Our systematic review showed uncertainty on the cause and effect when the relationship between axial pain and clinical factors was considered. It seems that several factors may affect the occurrence of axial pain after surgery and neurological recovery may be one. Yoshida et al. [47] found the relationship between neurologic recovery and axial pain, thus suggesting that the degeneration of the posterior horn of the spinal cord might cause chronic axial pain in patients with poor neurological function. However, other authors [6, 16, 19, 47] failed to confirm the relationship between neurological recovery and axial pain.

Cervical mobility may be another one. The relation between cervical mobility and axial pain has been noted [17, 31], as the decrease in cervical lordosis or increase in cervical kyphosis would produce more axial pain. However, other studies [6, 11, 15, 16, 19, 20] showed that postoperative axial pain did not correlate with postoperative cervical mobility.

Posterior muscle atrophy and detachment may play a pivot role in the pathogenesis of axial pain. Some studies [22, 40, 41] demonstrated that more posterior muscle atrophy following operative invasion may relate to more postoperative axial pain. Axial pain within a few months after surgery is due to surgical trauma to the muscles, whereas chronic axial pain derives from an imbalance of the flexor and extensor muscle strengths [29]. Therefore, the increase in muscle strength may diminish axial pain. In conventional open-door laminoplasty, the spinous processes are not returned to the correct anatomic position and the paravertebral muscles are not reattached to the spinous processes. With the spinous processes positioned obliquely after decompression, open-door laminoplasty is susceptible to result in axial pain [31]. Therefore, successful reconstruction of the laminae of vertebral arches is essential, because sinking or nonunion of the expanded laminae can induce postoperative axial pain [43]. In addition, detaching of the muscles from C2 or C7 has been regarded as another possible cause of postoperative axial pain [13, 41]. To expose the C3 lamina completely during conventional C3–C7 laminoplasty, the semispinalis cervicis (SSC) usually needs to be cut at its attachment point on the C2 spinous process. Iizuka et al. [13] repaired the SSC insertion at C2 spinous process after it had been transiently detached from the C2 during C3–C7 laminoplasty. However, they found that in some cases in their series, the morphological repair achieved was not maintained at the follow-up. The degree of extensor musculature repair affects postoperative cervical alignment. Most of the authors [13, 16, 41] have emphasized the importance of preserving SSC insertion at C2 and confirmed that this approach could prevent axial pain.

As the C7 spinous process is the origin of the trapezius, rhomboid minor muscles and the nuchal ligament, sacrificing this spinous process can cause great damage to the posterior musculature of the cervical spine. Sakaura et al. [34] found that the muscles at the cervicothoracic junction around the C7 spinous process played a central role in the development of this postoperative axial pain. Consequently, axial pain inherent in laminoplasty was reported to be reduced by preserving the C7 spinous process and its muscle and ligament attachments [6, 7, 32, 42]. Furthermore, Hosono et al. [9] revealed that C7, rather than the deep extensor muscles, was significantly related to axial pain. They also showed that detaching the extensor muscles from the laminae may cause mild pain early after surgery but not result in significant pain [9]. In contrast, other studies [16, 22, 23] demonstrated that preservation of the paraspinal muscles attached to C7 did not influence postoperative axial pain. There was no significant difference in the incidence or severity of axial pain between the groups with or without preservation of muscles attached to C7.

Both laminectomy and laminoplasty are safe and effective treatments for cervical myelopathy [4, 5, 14]. As laminoplasty is less destructive to posterior tissues than laminectomy, the more opportunity for muscles to be reattached to bone and the more preservation of bony covering of the dura mater in laminoplasty may contribute to less postoperative axial pain.

Several modifications using less invasive and reconstructive techniques have been undertaken during posterior cervical surgery to prevent the occurrence of axial pain after decompression (Table 3). These modifications aim at protecting the muscular attachment to spinous process and reconstruct the posterior structures. The reconstructive techniques [7, 22, 31, 32, 39, 41, 47] include reattachment of the spinous processes and musculatures, and preservation of deep extensor muscles and C2 or C7 spinous processes. Clinical studies have showed the advantages of these techniques over open-door laminoplasty in reducing axial pain and increasing cervical physiological lordosis. The less invasive techniques [16, 23, 33, 38, 40, 44, 46, 48] include skip or segmental partial laminectomy and

Table 3 Modifications of posterior cervical surgery techniques for reduction of axial pain

References	Modified techniques
Okada et al. [31], Yoshida et al. [47]	Laminoplasty with anatomic reattachment of the spinous processes and extensor musculatures
Kotani et al. [22], Shiraishi et al. [39]	Laminoplasty with deep extensor muscle preservation technique
Hosono et al. [7], Ono et al. [32]	C3–C6 laminoplasty with C7 spinous process preservation
Takeuchi et al. [41]	C4–C7 laminoplasty with C3 laminectomy
Kowatari et al. [23]	C4 laminoplasty
Shiraishi et al. [40], Yukawa et al. [48]	Skip laminectomy
Kato et al. [16], Tsuji et al. [44]	Selective open-door laminoplasty
Otani et al. [33], Yabuki et al. [46]	Segmental partial laminectomy (fenestration)

selective open-door laminoplasty. These techniques can reduce damage to the cervical structure and posterior muscles, and shorten the duration of orthosis application. Therefore, it may be effective in the maintenance of sagittal alignment and ROM as well as the reduction of postoperative axial pain.

To address issues of postoperative axial pain, several preventive measures have been taken into account. Edwards et al. [1] prescribed a soft collar and encouraged early active ROM and cervical isometric exercises as soon as comfort permitted after operation to decrease the incidence of axial pain. Kawaguchi et al. [17] reduced the amount of bone graft during operation, shortened the duration of orthosis application after surgery and advised patients on early exercise of the posterior neck muscles. They confirmed that these measures were effective in minimizing postoperative axial pain. The short duration of orthosis may have prevented muscle atrophy around the neck and contraction of the facet joints and maintained muscle balance of the cervical spine [12, 21].

Comparative studies have shown that some factors such as operative time [31], blood loss [7, 17, 31] and cervical collar application [17, 23, 40] may also be related to axial pain. However, it remains unclear whether the difference in the incidence or severity of axial pain is due to the different procedures or the different postoperative management.

This review has several shortcomings. Few studies were designed with adequate methodological quality, and most of the studies had small sample sizes. Additionally, the criteria for evaluating the axial pain were not defined consistently. Because of methodological variance in publications included in this systematic review, different results may be produced with high risk of bias.

Conclusions

Axial pain after cervical laminoplasty is very common. Multiple clinical factors may contribute to the incidence or severity of postoperative axial pain. Laminoplasty may not be the major cause of axial pain, but axial pain can be worsened by this procedure. The underlying mechanisms of axial pain are still not fully understood. Potential sources of axial pain include the cervical disc, musculature, facet joints, spinal cord and nerve roots. Early postoperative ROM exercise, shorter or no application of external immobilization, less surgical exposure, avoiding detachment of semispinalis cervicis muscle from C2 spinous process and reconstructing the extensor musculature as anatomical as possible are important considerations to prevent postoperative axial pain.

Further study is needed to clarify the etiology and pathological mechanisms underlying axial pain after laminoplasty and, consequently, to establish effective measures for prevention of this notorious complication.

Conflict of interest None.

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