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Technical Notes & Surgical Techniques

Skip laminectomy versus cervical laminectomy, an analysis of patient reported outcomes, spinal alignment and re-operation rates: The Leeds spinal unit experience (2008–2016)

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ABSTRACT

The two leading techniques in the UK utilised in the posterior decompression of the cervical spinal cord for cervical spondylotic myelopathy (CSM) are skip laminectomy (Skip LAMT) and open cervical laminectomy (LAMT). To the authors' knowledge no studies have directly compared effectiveness of skip laminectomy versus cervical laminectomy. This study assessed for differences in neck disability index, sagittal alignment and re-operation rates between both treatment options. A retrospective single institution cohort study was performed. Subjects underwent skip- or cervical laminectomy between 2008 and 2016. Patients whom had undergone previous cervical spinal surgery were excluded. Statistical analysis compared radiological differences in sagittal alignment of the vertebral bodies between C2-7 pre- and post-operatively in static lateral cervical spine radiographs using the Cobb method. A description of the surgical technique of skip laminectomy is also provided. In total 42 patients and 29 patients had skip and cervical laminectomy respectively. Both groups were matched pre-operatively in terms of cervical sagittal alignment ($p = 0.17$), age and gender. Median follow up time was 32 ± 23.1 (Range: 1–325) weeks. Post-operatively there was no difference in patient reported outcomes namely Visual Analogue Scale and Neck Disability Index between treatment groups compared to pre-operatively ($p = 0.64$ and $p = 0.75$). There was suggestion of difference in median length of hospital stay between treatment groups, however this was not statistically significant. There was no difference in sagittal alignment between groups following surgery ($p = 0.65$). Three patients (7.1%) in the skip laminectomy group and two patients (6.9%) in the cervical laminectomy group required revision surgery. No patients needed instrumentation. Skip laminectomy and cervical laminectomy deliver similar patient reported outcomes, sagittal alignment preservation and re-operation rates over this follow-up period.

1. Introduction

Cervical spondylotic myelopathy (CSM) is a common cause of spinal cord impairment in the elderly adult population [2,12,14]. The spinal cord is progressively compressed by degeneration of spinal components, leading to a reduction in function [4]. The treatment of choice for CSM is surgery, of which a variety of techniques have been developed. Surgery can be anterior and/or posterior [2,4]. With regards to posterior techniques, there is no consensus and there is considerable controversy as to which posterior approach leads to the best outcomes [2].

Cervical laminectomy is one of the oldest surgical methods for treating cervical spondylotic myelopathy and this technique has been shown to have some long term success [1,6,13]. However, the operation can compromise the integrity and alignment of the cervical spine and up to 21% of patients will subsequently develop kyphosis [3,7,8]. Further complications of laminectomy include segmental instability, perineural adhesions, and late neurologic deterioration have been recognized in the literature [1–4,6]. As a result of desire to avoid these complications, various methods of decompression were developed. Laminoplasty was introduced in 1982 to address issue of segmental instability and post-laminectomy kyphosis and skip laminectomy was first introduced by Japanese surgeons in 1998 to reduce side effects, including axial symptoms [4,9]. With respect to the latter procedure,

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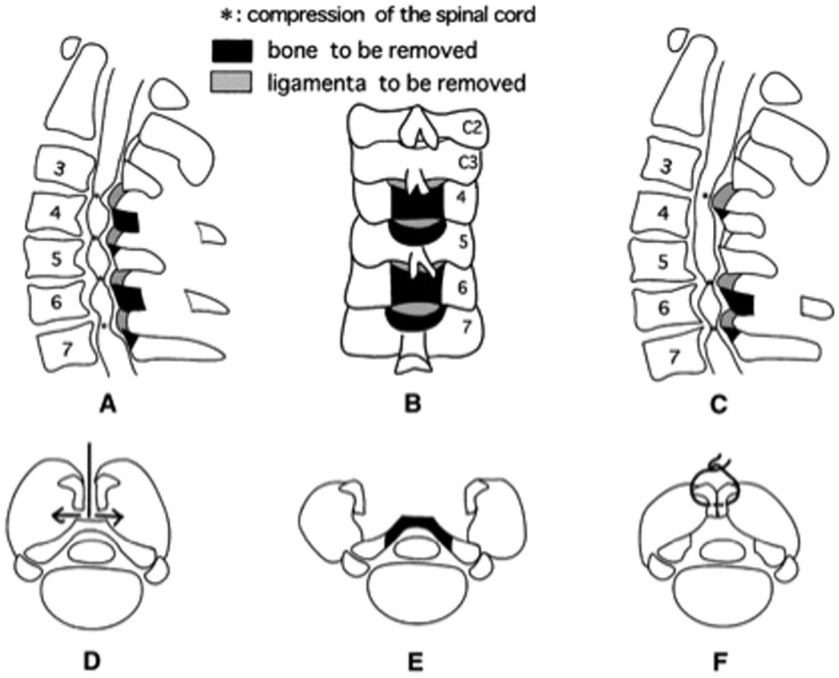

Fig. 1. Drawing demonstrating C4 and C6 skip laminectomy for a four level decompression between C3–4 and C6–7 via removal of alternate laminae (C4 and C6) and cephalad halves of C5 and C7 laminae with adjacent ligamentum flavum at those four levels.
Taken from Shiraishi [9].

there is limited evidence of its effectiveness. However, two studies discovered significantly improved axial pain and range of movement for skip laminectomy compared to laminoplasty [10,15]. Three studies including one randomised control trial found skip laminectomy had similar outcomes to laminoplasty with regards to improved Japanese orthopaedic association (JOA) scores and neck visual analogue score (VAS) [13].

However to the authors' knowledge, no studies have been performed comparing the outcomes for skip laminectomy and cervical laminectomy for the cervical spine. This study aimed to compare how neck disability index, sagittal alignment and re-operation rates changed in two matched groups pre- and post-operatively. This article also explains the surgical technique of skip laminectomy as described by Shiraishi [9].

2. Materials and methods

2.1. Data collection

Data was collected retrospectively for patients who underwent skip and cervical laminectomy between 2008 and 2015 at Leeds General Infirmary, UK. Patients who had undergone previous neck surgery or cervical spinal surgery were excluded from data analysis.

Data collected included patient demographics; indication for surgery; pre-operative cervical alignment; length of inpatient stay and details of follow up interval. X-ray and computer tomography (CT) scans of the cervical spine were analysed from the picture archiving and communication system (PACS) radiological database (AGFA Impax 6, Belgium).

2.2. Measurement of sagittal spinal alignment

Sagittal alignment was measured for each patient using the most recent pre-operative and postoperative imaging. Sagittal cervical alignment was evaluated on lateral plain radiography taken in a neutral position whilst standing or sitting, and the vertebral body angle (θ) between the inferior border of the C2 vertebral body and the superior border of the C7 vertebral body was measured using the method described by Cobb [11]. The differences in Cobb's angle pre- and post-operatively was calculated.

2.3. Statistical analysis

Mann Whitney U and Student *t*-tests were performed to look for differences in numerical data on Stata Statistical Software (StataCorp 2013, TX USA) including differences in spinal angles and follow up times.

2.4. Surgical technique of skip laminectomy

Skip laminectomy is a relatively new technique first described by Shiraishi in 2002 [9]. The principle aim is to achieve maximal decompression of neural tissue whilst maintaining muscular attachments to the spinous processes. This results in preservation of posterior neck extensor musculature compared to traditional cervical laminectomy, which is crucial as these muscles are known to be important in cervical stability. The following description is based on four level decompression between C3–4 and C6–7 as initially described by Shiraishi and demonstrated in Figs. 1 and 2 [9].

A standard posterior midline skin incision is performed between C4 and C6 spinous processes, followed by midline division of the nuchal fascia. The interval between left and right deep extensor muscles and midline is identified at C3–4, C4–5, C5–6 and C6–7 interspinous spaces and this is spread using a spatula-shaped retractor. This exposes the cephalad half of each lamina and ligamentum flavum at each interspinous space (Fig. 2A). This minimally invasive technique exploits the lack of tendinous attachments to the cephalad halves of the cervical laminae as they only attach caudally. As a result upper and lower margins of C4 and C6 spinous processes can be seen and the spinous processes split longitudinally. The spinous processes are split from each posterior arch using a high speed drill whilst leaving in place semispinalis cervicis and multifidus muscles (Figs. 1D and 2B). The muscles are then dissected laterally to expose the C4 and C6 laminae however this dissection does not extend beyond the medial aspect of each facet

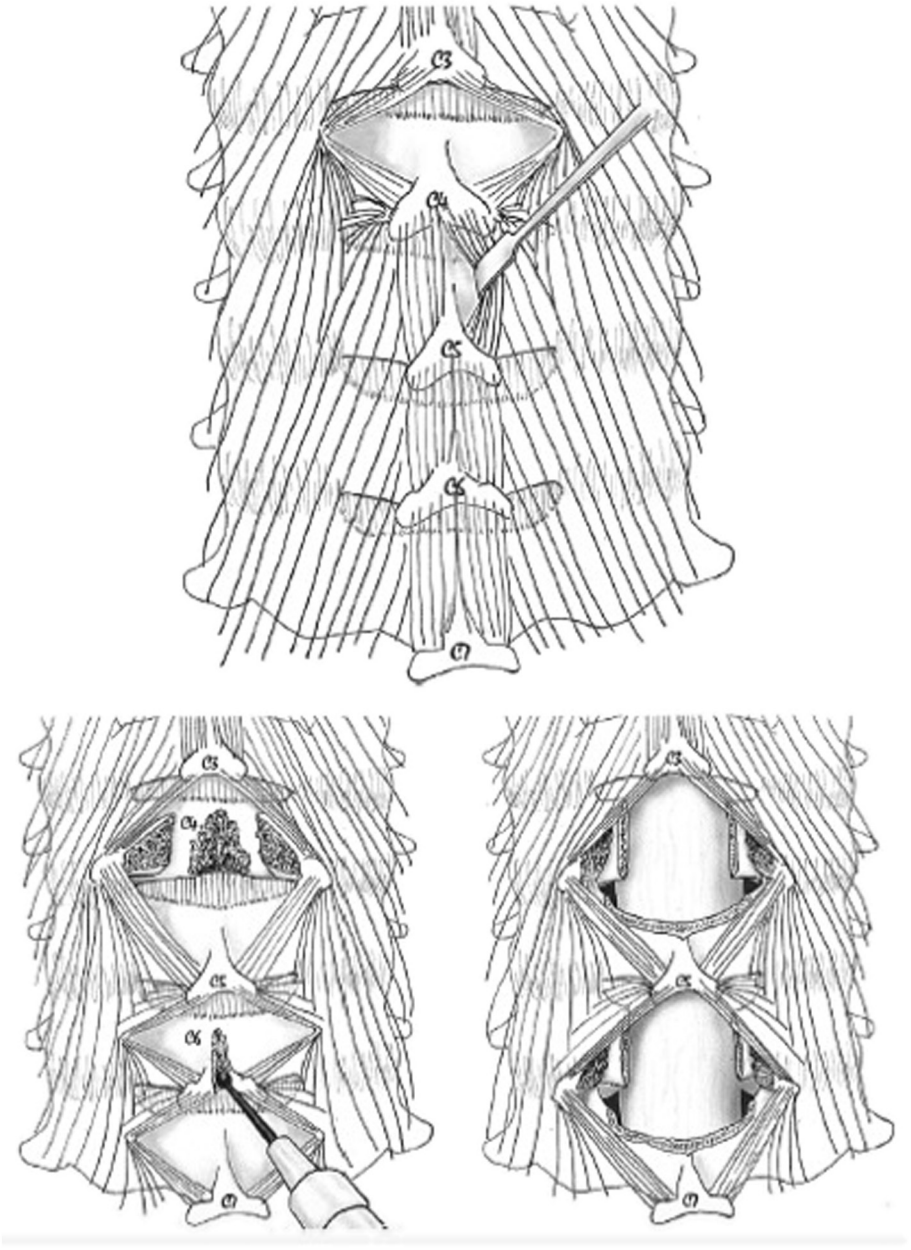

Fig. 2. Drawing demonstrating interval between midline and right and left extensor muscles at each interspinous space (Top). C4 spinous process is split longitudinally preserving muscular attachments and C6 lamina is also split using high speed drill (Bottom Left). Four level decompression is achieved (Bottom Right). Taken from Shiraishi [9].

joint capsule (Fig. 1E). Note that the posterior arches and spinous processes (along with their muscular attachments) are preserved for C3, C5 and C7.

The C4 lamina is removed in typical fashion, followed by the cephalad half of C5 and flavectomy at C3–4 and C4–5. The proximal portion of ligamentum flavum at C3–4 is removed from C3 lamina ventral aspect using a curved curette or Kerrison rongeur. The same is performed at C5–6 and C6–7. This results in decompression of the spinal cord at four levels between C3–4 and C6–7 via removal of alternate laminae namely C4 and C6 whilst preserving the C3, C5 and C7 posterior arches and muscular attachments of the semispinalius cervicis and multifidus muscles (Fig. 2C). Split halves of the spinous processes are then re-approximated with a stout suture and standard closure is then performed (Fig. 1F) [9].

2.5. Pre- and post-operative radiographic appearances of skip laminectomy

Fig. 3 demonstrates the pre- and post-operative appearances at 6 weeks and 2 years after a C4 and C6 skip laminectomy for multi-level chronic spondylotic myelopathy [9]. The reader can appreciate good early and persisting decompression of the cervical spinal cord has been achieved with preservation of posterior neck extensors when compared to traditional cervical laminectomy (Fig. 4) [5,9].

3. Results

3.1. Patient demographics and pre-operative pain and disability score analysis

Between 2008 and 2015, 42 skip laminectomies and 29 cervical laminectomies had post-op cervical spine images available and were

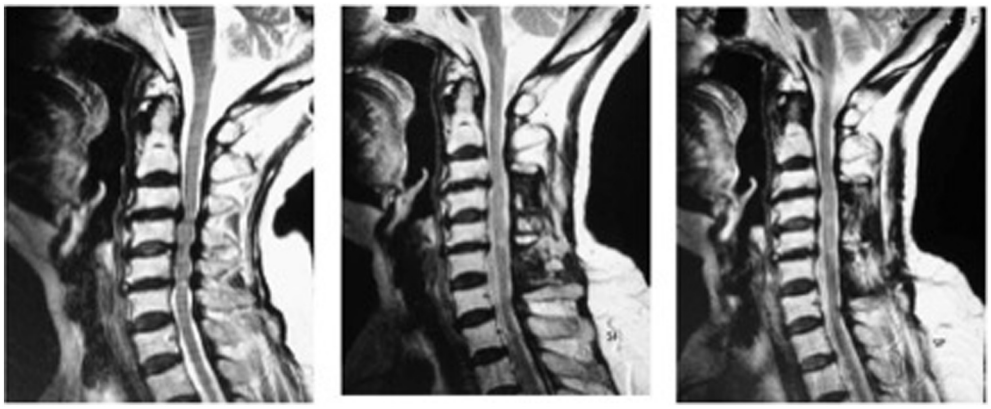

Fig. 3. Sagittal MRI demonstrating pre-operative multilevel cervical spinal cord compression and post-operative appearances following C4 and C6 skip laminectomy at 6 weeks and 2 years.
Taken from Shiraishi [9].

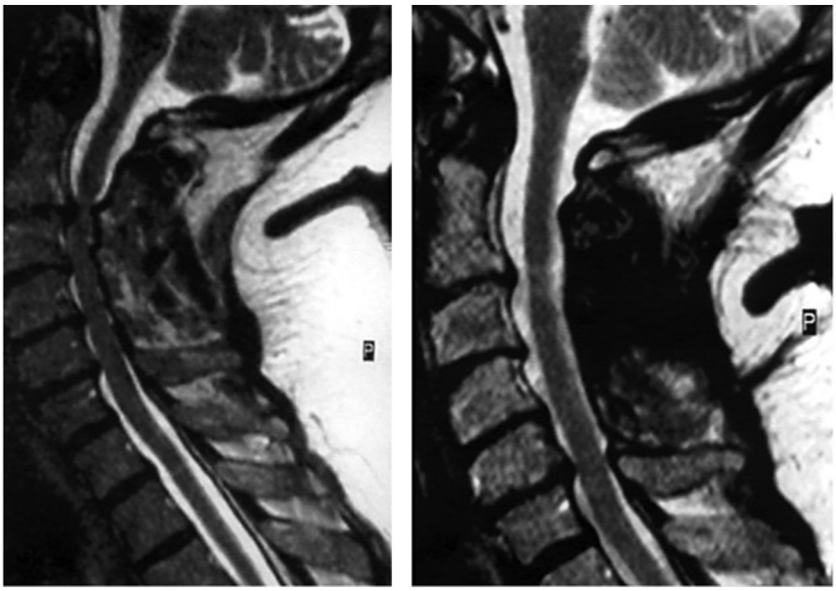

Fig. 4. Sagittal MRI demonstrating pre-operative cervical spinal cord compression and following traditional cervical laminectomy at C3–4.
Taken from Malcolm [5].

Table 1
Patient characteristics, median length of hospital stay, follow up intervals and pre-operative VAS and NDI scores for the skip and cervical laminectomy groups.

	Skip laminectomy	Cervical laminectomy	*p* value
Number of patients	42	29	
Age (median)	72	76	0.28
Male:female	28:14	21:8	0.61
Median stay (days)	3.5 ± 2.05 (1–29)	5 ± 4.78 (0–59)	0.16
Median follow up between operation and last scan of cervical spine (weeks)	32 ± 23.1 (1–325)	30 ± 25.0 (0.143–208)	0.24
Pre-op VAS (neck)	7.1 ± 3.1 (0 − 10)	8.0 ± 1.5 (4–10)	0.24
Pre-op VAS (arm)	7.2 ± 2.4 (1 − 10)	7.3 ± 1.9 (3 − 10)	0.69
Pre-op NDI (%)	45.7 ± 17.4 (12–74)	49.5 ± 14.5 (22–81)	0.36

Table 2
Median change in VAS and NDI scores for skip and cervical laminectomy groups.

	Skip laminectomy	Cervical laminectomy	*p* value
Median change VAS	1 (0–9)	1 (0–7)	0.64
Median change NDI	28 (0–64)	31.25 (4–40)	0.75

analysed. Patient characteristics and follow up times are presented along with pre-op Visual Analogue Score (VAS) and Neck Disability Index (NDI) in Table 1. These baseline characteristics were matched in both groups. Postoperatively there was a suggestion of difference in the length of hospital stay between skip and cervical laminectomy groups, however this was not statistically significant ($p > 0.05$).

Table 3
Matching of pre-operative spinal angles representing sagittal alignment and no difference in change of pre and post-operative angles between the skip and cervical laminectomy groups.

	Skip laminectomy	Cervical laminectomy	*p* value
Median pre-operative angle	17.9 ± 3.46 (2.5–46.4)	14.1 ± 4.35 (2.9–43.9)	0.17
Median difference between pre- and post-operative angles	−1.5 ± 2.71 (−20.5–18.7)	−1.8 ± 2.53 (−21.1–9.3)	0.65

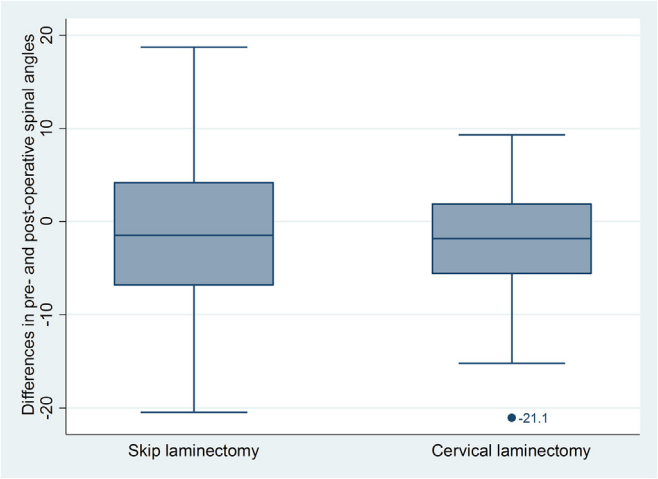

Fig. 5. Median difference in post-operative sagittal spinal alignment between skip laminectomy and laminectomy treatment groups.

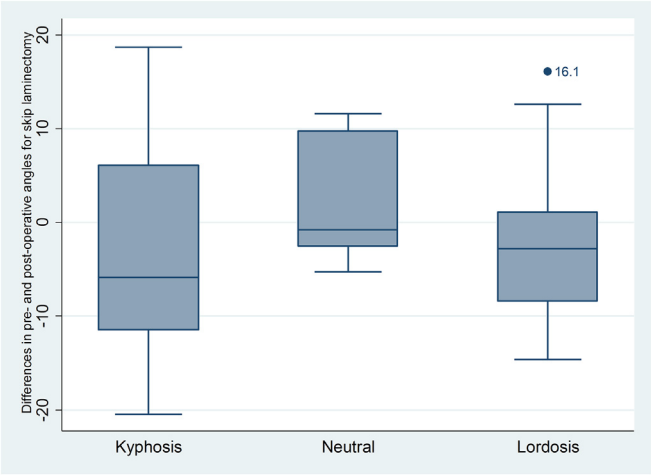

Fig. 6. Differences in pre and post-operative spinal angles, classified by cervical alignment for skip laminectomy patients.

Table 4
Summary of pre-operative spinal alignment for both treatment groups.

	Skip laminectomy (n-42)	Cervical laminectomy (n-29)
Kyphosis	6	5
Neutral	12	13
Lordosis	24	11

3.2. Post-operative pain and disability score analysis

Analysis of post-operative VAS and NDI demonstrated no difference between skip laminectomy and cervical laminectomy groups ($p = 0.64$ and $p = 0.75$ respectively) (Table 2).

3.3. Analysis of spinal sagittal alignment

Analysis of pre-operative angles between C2 and the superior part of C7 demonstrated good pre-operative matching of sagittal alignment between treatment groups ($p = 0.17$).

Analysis post-operatively demonstrated no significant difference in change in sagittal alignment between skip laminectomy and cervical laminectomy groups ($p = 0.65$) as shown in Table 3 and Fig. 5.

The number of patients who had kyphosis, lordosis or neutral spines pre-operatively is summarized in Table 4. Further subgroup analysis was performed to assess whether there were differences in sagittal alignment in the above subgroups following surgery. Both treatment groups were well matched pre-operatively in terms of alignment (Table 5).

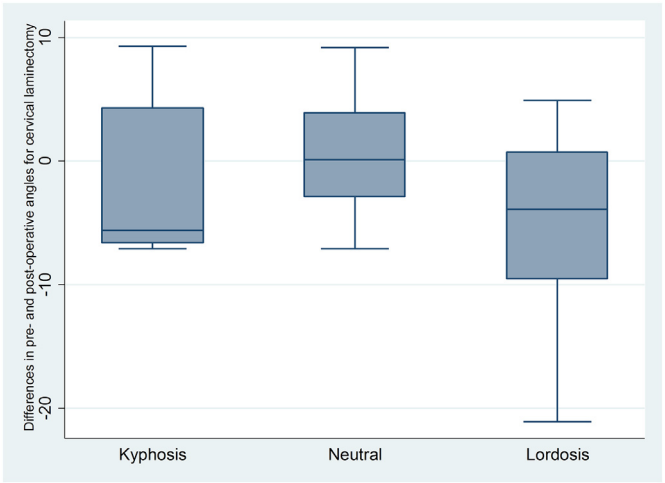

Fig. 7. Differences in pre and post-operative spinal angles, classified by cervical alignment for cervical laminectomy patients.

Differences in sagittal alignment pre and post-operatively were similar in the kyphosis, lordosis and neutral spine groups for both surgical techniques (Figs. 6, 7, Table 6).

3.4. Revision surgery and complications analysis

In the skip LAMT group, three patients (7.1%) required revision

Table 5
The median pre-operative angle across both groups, categorized by cervical pre-operative alignment.

	Skip laminectomy	Cervical laminectomy	*p* value
Median pre-op angle with kyphosis	17.8 ± 9.29 (11.4–34.1)	12.7 ± 2.66 (9.80–15.3)	0.22
Median pre-op angle with neutral spinal angle	5.91 ± 1.46 (2.5–8.8)	5.19 ± 1.37 (2.9–9.9)	0.43
Median pre-op angle with lordosis	24.0 ± 3.94 (10.1–46.4)	25.3 ± 7.21 (11.9–43.9)	0.72

Table 6
Median difference between pre-operative and post-operative Cobb angles across both surgical groups, categorized by pre-operative cervical alignment.

	Skip laminectomy	Cervical laminectomy	*p* value
Median difference between pre and post op angles with kyphosis	−5.85 ± 14.5 (−20.5–18.7)	−5.6 ± 9.29 (−7.1–9.3)	0.77
Median difference between pre and post op angles with neutral spinal angle	−0.8 ± 4.08 (−5.3–11.6)	0.1 ± 2.71 (−7.1–9.2)	0.41
Median difference between pre and post op angles with lordosis	−2.8 ± 3.67 (−14.6–16.1)	−3.9 ± 5.11 (−21.1–4.9)	0.33

surgery to the cervical spinal region. None of these procedures were at the same level of initial surgery. Two such patients had skip laminectomy and one had anterior cervical discectomy and fusion. There were two post-op wound infections and two post-op haematoma.

In the cervical laminectomy group, two patients (6.9%) required revision cervical laminectomies due to compression of the spinal cord. There were three post-op wound infections and one post-op haematoma.

4. Discussion

This study found no difference in surgical complications, radiographic and clinical outcomes between patients whom underwent skip cervical laminectomy (skip LAMT) and traditional cervical laminectomy (LAMT). There was a suggestion of a difference in median length of hospital stay between both groups, the skip cohort being shorter, however this was not statistically significant. More patients underwent skip laminectomy than traditional laminectomy, which reflects the preference for this technique at our institution.

Skip LAMT is a recently developed minimally invasive procedure. In a comparative study, Shiraishi et al. [9] reported that only 1 patient (2%) undergoing skip LAMT had newly developed axial pain, whereas 33 patients (66%) treated with laminoplasty (LAMP) had postoperative development or deterioration of axial pain. The atrophy rate of the deep extensor muscles in skip LAMT averaged 13%, whereas that in LAMP was 59.9%. In the LAMP group, three patients (5.7%) had C5 paresis, whilst none occurred in the skip LAMT group. Skip LAMT also had better postoperative ROM, relative to LAMP ($p < 0.05$). Skip LAMT was found to be less invasive to posterior extensor structures, including the deep extensor muscles, than LAMP. Additionally, skip LAMT was effective in preventing postoperative complications often seen after conventional LAMT and LAMP with adequate decompression of the spinal cord. Sivaraman et al. also reported less blood loss, shorter operative times, significantly improved axial pain scores, and significantly improved preservation of range of movement with skip LAMT, compared to LAMP [10]. The degrees of decompression with both techniques were similar. Interestingly, Yukawa et al. reported that no significant differences were seen between skip LAMT and LAMP, in terms of operative invasiveness, axial neck pain, cervical alignment, ROM, and clinical results [16].

In our cohort, pre-operatively, sagittal spinal alignment was matched across both surgical groups, enabling good comparison between techniques. The differences in spinal angle and follow up times were not significantly different between techniques and neither of the techniques was superior in regards to spinal angle outcomes. For patients with different cervical alignments pre-operatively, there was no significant difference in spinal angle changes after surgery for each technique. Kyphotic patients experienced a greater reduction in spinal angle than neutral spinal and lordotic patients. The absence of radiological difference was surprising despite higher expected muscle atrophy rate in the laminectomy group.

Prior to this study, no direct comparison between skip and standard laminectomy has been published in the literature. Indeed all previous comparison is between skip laminectomy and laminoplasty. Shiraishi reported higher muscle atrophy rate in laminoplasty group (59.9%) compared to skip laminectomy (13%) [9]. The expected muscle atrophy rate in laminectomy is expected to be similar given its similar approach, however in this study radiographic measurement of sagittal alignment was not conducted. Despite this higher muscle atrophy rate, radiographic sagittal alignment has been found to be no different between laminoplasty and skip laminectomy in a prospective randomised controlled trial [16]. This is in agreement with our study findings.

4.1. Limitations

There were several limitations to the study. Many of the cohorts whom underwent cervical or skip laminectomy were excluded due to incomplete scan data, leading to type II errors. There were more patients in the skip laminectomy group than the cervical laminectomy group, which may bias results. There may be measurement errors in how the spinal angles were measured. Since the study was retrospective, factors including psychiatric history, body mass index and smoking status were not measured or accounted for in the analysis. Importantly the follow-up period is short and perhaps 5–10 year follow-up studies will demonstrate superiority of one technique over the other.

5. Conclusion

In conclusion analysis of skip laminectomy and open cervical laminectomy in our institution revealed similar outcomes with regards to patient reported outcomes, sagittal alignment and complications. This suggests that patient or surgeon preference is appropriate to select best intervention to treat CSM.

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Conflict of interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

For this type of study formal consent is not required.

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Nil.

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