Laminarthrectomy as a surgical approach for decompressing the spinal canal: assessment of preoperative versus postoperative dural sac cross-sectional areal (DSCSA)

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Received: 22 August 2011 / Accepted: 28 February 2013 / Published online: 15 March 2013
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Abstract

Introduction Surgery for lumbar spinal stenosis (LSS) is today the most frequently performed procedure in the adult lumbar spine. Long-term benefit of surgery for LSS is well documented both in randomized and in non-randomized trials. In this paper, we present the results from laminarthrectomy as an alternative surgical approach, which have theoretical advantages over other approaches. In this study, we wanted to study the clinical and radiological results of laminarthrectomy. Dural sac cross-sectional areal (DSCSA) is an objective method to quantify the degree of central stenosis in the spinal canal, and was used to measure whether we were able to achieve an adequate decompression of the spinal canal with laminarthrectomy as a surgical approach.

Materials and methods All patients operated on with this approach consecutively in the period 1 January 2008 to 31 March 2009 were included in the study. All perioperative complications were noted. Clinical results were measured by means of a questionnaire. The patients that agreed to attend the study had an MRI taken of the operated level. DSCSA before and after surgery of the actual level were measured by three observers. We then performed a correlation test between increase of area and clinical results. We also tested for inter- and intra-observer reliability.

Results Fifty-six laminarthrectomy were performed. There were 17 % complications, none of them were life-threatening or disabling. 46 patients attended the study and answered the questionnaire. Thirty-four patients (83 %) reported clinical improvement, whereas six (13 %) patients reported no improvement, and two (4 %) patients reported that they were worse. Mean ODI was 23.0. Mean EQ-5D was 0.77. Mean VAS-score for back-pain was 3.1 and mean VAS-score for leg-pain was 2.8. Mean DSCSA were measured to 80 mm² before surgery and 161 mm² after surgery. That gave an increase of DSCSA of 81 mm² (101 %). We found a significant positive correlation between increase of area and clinical results. We also found consistent inter- and intra-observer reliability.

Discussion In this study, the clinical results of laminarthrectomy were good, and comparable with other reports for LSS. The rates of complications are also comparable with other reports in spinal surgery. A significant increase in the spinal canal diameter was achieved. Within the limitations a retrospective study gives, we conclude that laminarthrectomy seems to be a safe and effective surgical approach for significant decompressing the adult central spinal canal, and measurement of DSCSA, before and after surgery seems to be a good way to quantify the degree of decompression.

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Keywords Laminarthrectomy · Lumbar spinal stenosis (LSS) · Dural sac cross-sectional areal (DSCSA)

Introduction

Lumbar spinal stenosis (LSS) is recognized with increasing frequency as a cause of low back pain and sciatic pain. Today, surgery for LSS is the procedure most frequently performed in the adult lumbar spine [1]. The clinical entity “lumbar spinal stenosis” can be defined as a narrowing of the lumbar spinal canal with its contents. This leads to compression of nervous and vascular structures. LSS is a degenerative condition where the pato-anatomic change involves a bulging disc, hypertrophy of the ligamenti flavi and hypertrophy of the facet-joints. The symptoms are most commonly neurogenic claudication, or sciatic pain, or low back pain. The surgical solution is to decompress the stenotic part of the lumbar spine by removal of ligamenta flava, the lamina (whole or parts of it) and by performing a partial medial facetectomy. The main object of the surgical methods is to significantly increase the spinal canal diameter, and thereby improving the patients’ symptoms.

Randomized and non-randomized trials document that surgical treatment is significantly better than non-operative treatment both on short- and long-time follow-up [2–7]. Traditionally laminectomies are the most common surgical procedure that is performed. This is the surgical method that was used in the long-time follow-up studies [2–7]. The recent decades the Fenestration-procedures (e.g., laminotomies) [8–11] are presented as an alternative to laminectomies. Both surgical approaches are well documented, and have their proponents and opponents. Laminectomy are claimed to be more prone to instability, but gives a wide decompression, and is technical feasible. Fenestration procedures are more technical demanding, especially in the lateral recesses, but should be more stability preserving. Several studies show no significant differences in clinical results between the two methods [9, 12–16]. However, two studies favour fenestration procedures [12, 17].

A third alternative presented in the recent years is a surgical approach called laminarthrectomy. This approach gives a “mid-line” access, which provides a better visibility, and makes it easier to decompress in the lateral recesses. The posterior bony and ligamentous complexes are kept intact, which is considered to be stability preserving. Some studies report good clinical results that are comparable with other reports for surgical treatment of LSS [18–21].

Dural sac cross-sectional areal (DSCSA) is a way to measure the degree of central spinal canal compression [22]. It is unclear how much the preoperative DSCSA must

be increased to relieve the patients of their symptoms. To our knowledge, it is not published any studies that compare preoperative and postoperative DSCSA, or studies that shows a correlation between increase of DSCSA and patient satisfaction.

The main purpose of this retrospective study was to investigate whether a laminarthrectomy gives an adequate decompression of the spinal canal. We wanted to study if there was a significant increase of the area after laminarthrectomy. Secondary, we wanted to see whether the increase of DSCSA was correlated to the clinical results.

This study is approved of the Norwegian board of ethics and the Norwegian Social science Data services (Project number: 043.09).

Materials and methods

Patient selection

From the patients database, we collected all procedures registered with “ABC 56-Decompression of the lumbar spinal canal”, consecutively in the period 1-1-2008 to 31-3-2009 [Orbit 4.17; NCSP-code (NOMESCO classification of surgical procedures)] [23].

1. The patients that were decompressed with laminarthrectomy as were identified. The operation protocols collected, and perioperative complications noted.
2. The patients that were included in the study were asked to answer a questionnaire containing Oswestry Disability Index (ODI version 2.0), EQ-5D, VAS score for lower back pain (LBP), VAS-score for sciatic pain, and self-reported effect of the operation. ODI and EQ-5D are reliable questionnaires, and evaluated in several studies [24–28].
3. The patients that did not have MRI preoperatively were excluded. A postoperative MRI (Siemens, Erlangen Avanto 1.5T) of the remaining patients were taken to compare DSCSA preoperatively and postoperatively. The area was measured on the axial T2 images taken parallel to the operated disc. The area that was measured was the smallest area in the disc level. When the patients had two or three level disease, the level with the smallest area was used. The radiological measurements were done by three investigators (two radiologists, and one spinal orthopaedic surgeon). They did the measurements independently twice. We then calculated the increase of area in square millimetres, for each patient.

All patients that agreed to join the study signed an informed consent paper.

Surgical procedure

After an ordinary mid-line incision the dorso-lumbar fascia, and the multifidus-muscles are detached from the processus spinosus uni-laterally. An osteotomy at the basis of the processus spinosus, over and under the actual level is then performed. The processus spinosus with intact supraspinal and interspinal ligaments are withdrawn contralaterally with a self-retaining contractor. The decompression is performed by removing the ligamenti flavi and performing a laminotomy of the lower part of the upper lamina, and upper part of the lower lamina together with a partial removal of the medial part of the facet joint. At least one third of the lamina is kept intact. Caution is taken to leave at least ten millimetre bridges of the basis of the processus spinosus to preserve a platform for the processus spinosus to unite. The osteomiized processus spinosus with intact supraspinal and intraspinal ligaments are left to fall back in their original position after removing the retractors (Fig. 1).

Statistics

The statistical analyses were performed with SPSS 18.0 for Windows (PASW Statistics, IBM). We tested for correlation between “degree of decompression”, measured as mm increase in DSCSA, and the patients’ self reported effect of surgery, Pearson correlation test. Descriptive analyses were performed, calculating mean, median and range. To test for inter and intra-observer differences a visual test was performed, plotting observations into XY-graphs. To investigate any differences in intra-observer observations, we performed

a paired-sample T test. And to test the inter-observer consistency, a one-way ANOVA test was performed.

Results

Figure 2 shows the flow chart from 1 January 2008 to 31 March 2009. All patients had LSS without instability. Mean age was 65.3 years (33–86). There were 27 (59 %) male. The number of levels decompressed was mean 1.59 (1–3). Of the 46 patients, 22 (48 %) were operated in one level, 21 (46 %) were operated in two levels, and 3 (6 %) patients were operated in three levels. Mean duration for follow up were 14.7 months (range 1–24 months).

Complications

A total list of all perioperatively complications are listed in Table 1. There were no life-threatening or disabling complications (Table 1).

Patient satisfaction

Thirty-four patients (83 %) reported improvement, six (13 %) reported no improvement, and two (4 %) reported that they were worse (Fig. 3). All patients answered the questionnaire, and the clinical results are listed in Table 2.

Dural sac cross-sectional areal

The mean DSCSA preoperatively was 80 mm² (range 20–160 mm²). Postoperatively the mean DSCSA was

Fig. 1 Illustration of laminarthrectomy used to decompress the spinal canal

Fig. 2 Flow chart over the patients inclusions and exclusions **Table 1** Patients operated with laminarthrectomy for lumbar spinal stenosis

	Percent (%)	No.
Dural tear	5	3
Postoperative hematoma	2	1
Wrong-level operation	4	2
Proximal femur fx	2	1
Postoperative confusion	2	1
Superficial wound infection	2	1

Complications identified after surgery ($N = 56$)

161 mm² (range 30–280 mm²). This is an increase of 81 mm² (101 %).

There was a significant correlation between the degree of decompression and the patient self reported effect of surgery (Pearson -3.71 ; $p = 0.006$). When evaluating the XY-graphs (Fig. 4), the visuals gave the impression that there was a consistency—both intra and inter observer. Performing a paired-sample T test confirmed there was no significant differences between the intra-observer observations ($p > 0.05$ in all three pairs). To test the inter-observer consistency, a one-way ANOVA test was performed. This further yielded no significant results of differences between the observers ($p = 0.545$).

Discussion

The main goal of surgical treatment of LSS is to decompress the stenotic spinal canal. To achieve this goal of decompression, most of the ligamenta flava and the lamina (whole or parts of it) are removed. To decompress the lateral recesses you also have to do a partial medial facetectomy. Today, there are two main surgical approaches to achieve this decompression, laminectomies, and fenestration-procedures. Laminectomy-procedures are prone to instability, fenestration-procedures are more technically demanding, especially in the lateral recesses. Subramaniam

Fig. 3 Self-reported effect of laminarthrectomy for patients operated for LSS**Table 2** Clinical and survey results during follow up for patients operated with laminarthrectomy for lumbar spinal stenosis ($N = 46$)

	Median	Mean	Range
Age (years)	59	65.3	33–86
ODI	29	23.0	0–64
EQ-5D	0.74	0.77	0.28–0.98
VAS back-pain	4	3.1	0–8
VAS leg-pain	3	2.8	0–7
Time to follow-up (months)	16	14.7	1–24

et al. [29] point this out as their in vitro study where they conclude that laminoplasty (laminotomi) leaves the spine in a significantly more stable condition than laminectomy. However, laminoplasty failed to relieve stenosis completely.

Laminarthrectomy keeps the biggest advantages of both laminectomy-procedures and fenestration-procedures. Laminarthrectomy is a surgical approach that is theoretical stability preserving, because the lamina is not totally

Fig. 4 X/Y Shown below are the intra-observer visuals plot (observed differences pre-post)

removed, and the supraspinal and intraspinal ligaments are left intact. This approach also gives a midline access that offers better visualization, especially in the lateral recesses.

The short-time clinical results after laminarthrectomy are good, and comparable with other reports both with regard to functional ability (ODI and EQ-5D), sciatic pain, low back pain, self-reported effect of surgery, and rate of complications. Malmivaara et al. [6], who had a comparable patient material reported ODI-score 2 years postoperatively of 21. Celik et al. [12], who compared total laminectomy with microdecompressive laminotomy reported in their material ODI-score 2 years postoperatively of 23. In this study, the patient material also was comparable in terms of age and sex. In the present study, postoperatively ODI-score was 23. Jansson et al. [30] investigated preoperative and postoperative quality of life in 230 patients operated for LSS, and reported a postoperative EQ-5D to 0.64. Hansson et al. [31] investigated the level of preoperatively and postoperatively EQ-5D in 777 orthopaedic procedures, and found that surgery for LSS had a median EQ-5D 1 year postoperatively of 0.62. In the present material, the EQ-5D was 0.77. Unfortunately, we cannot report the clinical improvement, since we did not have preoperative clinical measurements. However, the postoperatively results are in agreement with others [2–4, 6, 7]. In orthopaedic surgery, recordings of quality of life after total hip replacement (THR) showed that this procedure was one of the most effective treatments available. THR for that reason has become more or less a golden standard in these respects. For comparison, THR scores postoperatively an EQ-5D of 0.796 [31].

The incidences of dural tears was in the present study 5.4 %. This is in agreement with Tafazal et al. [32] who reported incidental dural tears in 1,549 spinal surgery cases, to be 8.5 %. Other complications like postoperatively hematomas and wound infections, also corresponds with other studies [2–4, 6, 7].

There seems not to be agreement upon the magnitude of DSCSA reduction that gives clinical symptoms. Schonstrom et al. (using CT with intrathecal contrast) reported that

healthy individuals had a DSCSA of $178 \text{ mm}^2 (\pm 50 \text{ mm}^2)$, whereas LSS patients planned for decompressive surgery presented a DSCSA of $89.6 \text{ mm}^2 (\pm 35.1 \text{ mm}^2)$. Sirvanci et al. (using MRI) found that of patients scheduled for elective decompressive surgery, 60 out of 63 had a DSCSA $< 100 \text{ mm}^2$ [33]. Sigmundsson et al. [34] found that morphological changes of MRI, correlated only to a limited extent to the patients symptoms, and Boden et al. [35] showed that a many of asymptomatic people had spinal stenosis. On the other hand, Ogikubo et al. found that a decrease in area was a strong predictor of the patients' symptoms [36]. This discussion emphasizes the importance of assessing both the patients' symptoms and the radiological findings in diagnosing LSS.

There are three types of LSS: central canal stenosis, the lateral recesses stenosis, and foraminal stenosis. Foraminal stenosis is outside the spinal canal, and must be classified in another matter. Although classically central and lateral stenoses are described as distinct entities, the patients will always have a combination of both. This method of quantifying the degree of stenosis is only used in patients with a significant central canal stenosis component. It is not recommended for evaluating lateral recess stenosis [33]. An evaluation of the degree of lateral recess stenosis must come in addition, and also be correlated with the patients' symptoms.

The present study shows an increase of DSCSA of 101 % postoperatively, to a mean of 161 mm^2 , which is close to what Shonstrom et al. [22] reported in a normal population. Therefore, laminarthrectomy gives a significant increase of the DSCSA in a stenotic spinal canal.

There was a positive correlation between degree of decompression and clinical effect of the surgical procedure. To our knowledge, this has not been documented before. Rapala et al. [37] presented a material of 33 patients, where surgical treatment significantly increased dural sac area, measured with a CT scan midpedicular. However, this study did not report a correlation to clinical symptoms. Gunzburg et al. [18] compared the interfacet bony canal diameter before and after surgery. They did not find that

successful surgical treatment correlated with the interfacet bony canal diameter.

The present study showed that the clinical results are better with a wide decompression. However, this patient material is small, so firm conclusions cannot be drawn. This paper does not answer how much decompression that is needed for relieving the patients for their symptoms, both in terms of short-time results or long-time results. But, our results indicate that it is necessary with a significant decompression. We cannot find any threshold value for defining symptomatic LSS, neither can we present a minimum value for the degree of decompression that is needed. However, in this study, a large decompression gives better clinical results than a smaller decompression.

This method of quantifying the degree of stenosis before and after surgery, by using DSCSA, is reproducible and with today's technology easy to perform. The inter-, and intra-observer observation are consistent. It seems to be useful in a clinical setting when evaluating the individual patient's effect of the surgical procedure. The results can be used not only to quantify the degree of decompressive surgery in laminarthrectomie, but also quantify the degree of decompressive surgery with other surgical approaches. In a scientific setting, this method can be useful. It is an objective radiological parameter, when different methods are compared.

However, the present study is a retrospective study, and its main weakness is that ODI and VAS measures cannot be compared retrospectively if not taken at baseline. Further research, preferable a long-time prospective randomized controlled trial, needs to be done to evaluate the clinical outcome of laminarthrectomy.

Conclusion

We conclude that laminarthrectomy is a surgical approach that gives good clinical and radiological results decompressing LSS without instability. There was a positive correlation between degree of decompression, and improvement of the patients' symptoms. Measurement of DSCSA, before and after surgery seems to be a good way to quantify the degree of decompression.

Acknowledgments We want to thank Ari Bertz, MD, for his illustrations of the surgical procedure.

Conflict of interest None

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