Yasuo Saruhashi
Kanji Mori
Akitomo Katsuura
Shinobu Takahashi
Yoshitaka Matsusue
Sinsuke Hukuda

Evaluation of standard nucleotomy for lumbar disc herniation using the Love method: results of follow-up studies after more than 10 years

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Y. Saruhashi (✉) · K. Mori · A. Katsuura
S. Takahashi · Y. Matsusue
Department of Orthopedic Surgery,
Shiga University of Medical Science,
Shiga 520-2192, Japan
Tel.: +81-77-5482252,
Fax: +81-77-5482254,
e-mail: saruhashi@belle.shiga-med.ac.jp

S. Hukuda
Tane-daini Hospital, Osaka, Japan

Abstract A retrospective analysis of long-term follow-up results more than 10 years after a standard nucleotomy for lumbar disc herniation with the Love method was done to determine the effectiveness of this procedure. Nucleotomy according to Love was the standard treatment for lumbar disc herniation before the various minimally invasive alternatives were recently introduced. Without long-term follow-up analysis of Love operations, evidence-based evaluation of those new methods is impossible. We believe that the standard nucleotomy procedure should now be evaluated precisely. In this study we present a comparison of 1-year follow-up results to the results more than 10 years after lumbar nucleotomy. Seventy-six consecutive patients who had undergone lumbar nucleotomy were identified. It was possible to assess 54 (71.1%) of the cases more than 10 years after sur-

gery. The initial and final outcomes were assessed using the MacNab classification and the Japanese Orthopaedic Association (JOA) score. With the MacNab classification a successful outcome 1 year after surgery was achieved in 87.0% of the cases. At the final follow-up, this result was reduced to 74.1%. Seven patients required a second operation and patients under 21 years of age were at risk for reoperation. Patient overall satisfaction with the results of the standard nucleotomy was high. The disc height of the operation site significantly decreased after surgery; nevertheless, this did not affect the clinical outcome. A standard lumbar nucleotomy according to Love is a safe and reliable method of treating selected patients with lumbar disc herniations.

Keywords Lumbar disc herniation · Nucleotomy · Long-term follow-up

Introduction

A nucleotomy following Love's method [14] had been the standard treatment until recently for the care of lumbar disc herniation when nonoperative treatments had failed. However, there are few known reports of long-term follow-up results of a standard lumbar nucleotomy [3, 7, 16]. Recently, various minimally invasive alternatives have been offered for the management of lumbar disc disease [13, 18]. Good results for microsurgical discectomy [19, 25], percutaneous nucleotomy [20], and percutaneous laser-as-

sisted discectomy [2] have all been reported. Recent evidence has suggested that complications from the use of these techniques may worsen the neurological status and back pain, because of wrong indications and inexperience [6, 22]. We believe that a reevaluation of the simple and conventional standard nucleotomy is needed.

Materials and methods

A total of 76 consecutive patients (59 males and 17 females) who underwent a standard lumbar nucleotomy after Love [14] from

Table 1 MacNab classification

Excellent	No pain; no restriction of activity
Good	Occasional back or leg pain of sufficient severity to interfere with the patient's ability to do his or her normal work, or to enjoy leisure activity
Fair	Improved functional capacity, but handicapped by intermittent pain of sufficient severity to curtail or modify work or leisure activities
Poor	No improvement or insufficient improvement to enable increase in activities; further operative intervention required

Table 2 Japanese Orthopaedic Association (JOA) score (range 0–29 points)

Subjective symptoms (9 points)	
Low back pain	
3:	None
2:	Occasional mild pain
1:	Frequent mild or occasional severe pain
0:	Frequent or continuous severe pain
Leg pain or tingling	
3:	None
2:	Occasional slight symptoms
1:	Frequent slight or occasional severe symptoms
0:	Frequent or continuous severe symptoms
Gait	
3:	Normal
2:	Able to walk farther than 500 m, although it results in pain, tingling, or muscle weakness
1:	Unable to walk farther than 500 m, because of leg pain, tingling, or muscle weakness
0:	Unable to walk farther than 100 m, because of leg pain, tingling, or muscle weakness
Clinical signs (6 points)	
Straight-leg raising (including tight hamstrings)	
2:	Normal
1:	30°–70°
0:	Less than 30°
Sensory disturbance	
2:	None
1:	Slight disturbance (not subjective)
0:	Marked disturbance
Motor disturbance (manual muscle testing)	
2:	Normal (grade 5)
1:	Slight weakness (grade 4)
0:	Marked weakness (grade 0–3)
Restriction of the ability of daily life (14 points)	
Turning over while lying down	
0:	Severe restriction
1:	Moderate restriction
2:	No restriction
Standing up	
0:	Severe restriction
1:	Moderate restriction
2:	No restriction

Washing oneself

- 0: Severe restriction
- 1: Moderate restriction
- 2: No restriction

Leaning forward and keeping standing

- 0: Severe restriction
- 1: Moderate restriction
- 2: No restriction

Sitting more than 1 h

- 0: Severe restriction
- 1: Moderate restriction
- 2: No restriction

Lifting or holding something heavy

- 0: Severe restriction
- 1: Moderate restriction
- 2: No restriction

Gait

- 0: Severe restriction
- 1: Moderate restriction
- 2: No restriction

Bladder function (minus 6 points)

- 0: Normal
- 3: Mild dysfunction
- 6: Severe dysfunction

September 1979 to September 1988 in our department were investigated retrospectively. Of the 76 patients, we were able to evaluate the recovery process after more than 10 years following the operation in 54 cases (71.1%, 39 males and 15 females). One patient died 6 years after the operation of causes having no connection with the lumbar operation. We could not examine the other 21 patients.

Conservative therapy, including medication, epidural block, traction, and orthosis, had failed for at least a month in all of the patients operated on for radicular pain. At the preoperative examination all patients clearly presented a radiological picture of lumbar disc herniation using myelography, CTM, and/or MRI. We added a selective nerve root block to detect an impaired nerve root, if necessary. It was the practice of the senior authors to use a standard lumbar nucleotomy for all such patients. Each patient was fitted with external bracing for 3 months following surgery.

We evaluated the clinical results according to the MacNab classification [15] (Table 1) system and the Japanese Orthopaedic Association (JOA) score [12] (range: 0–29 points; Table 2). Scores were measured 1 year after surgery and were examined again at the long-term follow-up. An improvement in JOA score was calculated as follows:

$$\text{Improvement (\%)} = \frac{\text{posttreatment score} - \text{pretreatment score}}{\text{maximum normal score} - \text{pretreatment score}} \times 100$$

A questionnaire was sent to all 54 patients and 47 patients (87.0%) completed it. They were asked about their employment status, patient satisfaction, and lumbar spine mobility. We took follow-up radiographs of the lumbar spine in 33 patients and investigated the disc height and instability of the operated site. For 7 patients who were classified as “fair” by MacNab classification on the final examination, we performed MRI examinations.

The SPSS mathematical program was used and the data were evaluated by an unpaired Student's *t*-test, Pearson's chi square test, and multivariate analysis. Variance is indicated in terms of standard deviation and considered significant at $P < 0.05$.

Table 3 Outcome evaluation according to MacNab classification ($n=54$)

1 year outcome	Final outcome			
	Excellent	Good	Fair	Poor
Excellent	28	1	3	3
Good	2	8	1	1
Fair	0	1	3	2
Poor	0	0	0	1

Results

Age at time of operation for the 76 patients ranged from 13 to 63 years (mean, 34.8; standard deviation, 13.5). In the 54 patients in whom we could evaluate the process of the operation more than 10 years later, the age at the time of operation ranged from 13 to 63 years (mean, 37.1±13.4). The follow-up period was from 10 to 19 years, 1 month (mean, 13 years, 2 months). Forty-eight patients had a one-level lumbar nucleotomy and six had a two-level lumbar nucleotomy. Four had a nucleotomy at L3–4, 35 at L4–5, and 21 at L5–S1. The complication rate was 5.6% (3 cases) and there were no mortalities. There were two dural tears and one superficial wound infection.

Overall, the patients showed a very rapid and significant clinical recovery. Overall improvement of JOA scores at 1 year was 78.1%. After the operation, their scores significantly increased from 9.4±4.1 to 24.7±4.1 ($P<0.005$) at the 1-year follow up. Preoperative JOA score, type of herniation, number of operation levels, days of hospital stay, duration between onset and the operation, presence or absence of complications, sex, age at the operation, height, weight, body-mass index, and presence or absence of a reply for a questionnaire were all thought to be potential determinants for improvement of JOA scores. A multiple regression analysis with improvement of JOA scores as the dependent variable and the above 12 factors as independent variables revealed that no factor was significant.

The excellent and good categories of the MacNab classification were noted as “success”; otherwise, fair and poor were noted as “failure.” We classified the seven patients who received reoperation as “poor.” The results are presented in Table 3. Success was achieved in 87.0% of the cases at 1 year, and this success rate decreased to 74.1% at the final follow-up. However, there was no significant difference in the distribution of the MacNab classifications between the 1 year and final follow-up.

According to the clinical course, patients were divided into two groups as described below. Forty-seven patients had one operation (group 1), while 7 received a reoperation after the first nucleotomy (group 2). The characteristics of the patients are summarized in Table 4. The duration between onset and operation in group 1 and 2 were

Table 4 Summary of patient profile (values are mean ± SD)

	Group 1 ($n=47$, 87.0%)	Group 2 ($n=7$, 13.0%)
Ratio of males to females	34:13	5:2
Age at first operation	38.3	29.1*
Operation levels	One level: 42 Two levels: 5	One level: 6 Two levels: 1
Height (cm)		
Male	168.7±7.2	169.0±5.0
Female	153.7±5.8	157.9±0.1
Weight (kg)		
Male	59.8±9.0	62.9±7.4
Female	54.4±7.8	56.5±0.7
Time between onset and operation	4.9 months	4.7 months
Hospital stay (days)	35.0	36.0
Complications (3 cases, 5.6%)	Two dural tears and one wound infection	—

* $P<0.05$ (significant difference compared to age at the first operation in group 1)

Table 5 Herniation type (60 disc levels). The protrusion type includes the subligamentous extrusion type

Type of herniation	Group 1 (52 disc levels)	Group 2 (8 disc levels)
Protrusion	40 (76.9%)	6 (75.0%)
Extrusion	9 (17.3%)	2 (25.0%)
Sequestration	3 (5.8%)	—

4.9 months and 4.7 months, respectively. The age at the first operation in group 2 was significantly younger than that of group 1 ($P<0.05$). However, there was no significant difference in height, weight, duration between onset and the operation, or time of hospital stay between groups 1 and 2. We classified the disc herniations as protrusion type, extrusion type, and sequestration type. The type of herniation is shown in Table 5, and there was no statistical difference of the type distribution between the two groups. The causes of reoperation included four cases of recurrence of herniation, two cases of nerve root irritation by scar tissue, and one case of spinal instability. We performed nucleotomy in four cases again, stripping the scar tissue from the nerve root in two cases and performing anterior interbody fusion in one case.

In group 1 (47 patients), improvement of JOA scores at 1 year and the final follow-up was 79.4% and 75.9%, respectively. Their scores increased from 9.6±4.1 to 25.2±2.9 ($P<0.005$) at the 1-year follow-up and then were nearly maintained, to 24.8±3.9, at the final follow-up. For group 2

Table 6 Improvement in JOA score ($n=54$; values are mean $\pm$ SD)

Group	Before operation	1 year	Final	Improvement at 1 year	Final improvement
Group 1	9.6 $\pm$ 4.1	25.2 $\pm$ 2.9	24.8 $\pm$ 3.9	79.4%	75.9%
Group 2	7.6 $\pm$ 3.5	21.7 $\pm$ 8.4	–	69.2%*	–

* $P<0.05$ (significant difference compared to improvement in 1 year for group 1)

(7 patients), improvement of JOA scores at 1 year was 69.2% (Table 6). Group 1 patients showed a greater improvement than those in group 2 at the 1-year follow-up ($P<0.05$).

In a further analysis, clinically deteriorated patients ($n=11$), including group 2 and 'fair' patients at the final follow-up, were selected. Seven of the 11 patients in the deteriorated group showed deterioration within 5 years, 2 at 5 years, and 2 10 years after the operation.

The questionnaire revealed that 89.4% of patients were satisfied with their operation. Overall, 76.6% of the patients returned to the same job or school on an average of 2.9 M, whereas 14.9% changed their job and 4.3% could not get a job. A further 57.4% did not feel any disability in lumbar mobility, 27.6% complained of some disability, and 38.3% of those who had experienced disability were forced to suspend their business or school activities after the operation.

We took X-ray films of the lumbar spine for more than 10 years for 26 cases in group 1. The disc height of the operation site significantly decreased from 8.8 mm before the operation to 7.1 mm at the final follow-up ($P<0.0005$). However, there was no statistical difference in disc height between the 'fair' group and the 'good, excellent' group. Three cases showed bony fusion in the operated disc space, and two cases had newly developed instability, which indicated a posterior extended angle (>3 deg) in the flexion position. We found a recurrence of disc herniation in four out of seven 'fair' cases by MRI examinations. There were three recurrent herniations at the same site of the first operation, and one recurrence on the same level but on the opposite side.

Discussion

Fifty-four patients with a lumbar disc herniation who underwent a lumbar nucleotomy after Love were followed-up for more than 10 years. Patients who had no response to conservative treatments for at least 1 month prior to the operation became surgical candidates. Application of these criteria resulted in good clinical improvement. A success rate of 87.0% was achieved when checked 1 year after the operation. This decreased to 74.1% at the final follow-up; however, it was not significant.

Studies have shown that the natural history of lumbar disc herniation has a good prognosis. Bed rest, instructions for proper care, and analgesics are usually sufficient therapeutic measures [27]. There is still controversy, however, as to whether conservative or surgical treatment is better for lumbar disc herniation. Because of the considerable variations in lumbar disc herniation, treatment should be decided upon according to the degree of pain and the improvement achieved. The timing of surgery has also been the subject of much debate. Our average interval between onset and operation was 4.9 months in group 1 and 4.7 months in group 2. It has been noted that an extruded or sequestered disc has the potential to be resolved by phagocytes [11]. We believe that an explanation regarding the natural history and spontaneous regression of lumbar disc herniation should be given to patients and allow them the chance to receive appropriate conservative treatment.

We compared the results of group 1 (one operation) and group 2 (reoperation). In this study, there was no statistical difference between groups 1 and 2 for the type of herniation. Hirabayashi et al. stated that the incidence of reoperation was significantly higher in patients with protrusion-type herniation than in those with extrusion-type or sequestration-type herniation [10]. In the present study of 54 cases, the number of cases might be too small to find a relationship between the type of herniation and incidence of reoperation. Group 1 patients were improved more than those in group 2 at the 1-year follow-up. It is suggested that the low score of group 2 on the first examination might have had an influence on those results. However, care must be taken for those patients with a low score at the 1-year follow-up, as they are apt to receive reoperations. Seven patients had a reoperation after the first nucleotomy. The present study revealed that younger patients tended to be subjected to reoperation. It was found that the incidence of second operations was significantly higher in teenagers than in older patients [10]. It is important to note that proper lumbar orthosis and low-back muscle exercise are essential in order to prevent recurrence, especially in younger patients who have high levels of physical activity. The disc height of the operation site significantly decreased after surgery, as another report has suggested [23]; nevertheless, this did not affect the clinical outcome of the patients in our study.

The efficacy of lumbar disc herniation treatment is dependent on careful clinical and radiological patient selection [9, 21]. There are familial [17, 26], psychological [24], social [4], and physical [1, 8] predisposing factors involved with lumbar disc herniation, and candidates for surgery must be carefully selected with those factors in mind. Currently, the general trend is to use various kinds of minimally invasive alternatives [2, 13, 18, 19, 20, 25], even though recent evidence has suggested complications because of wrong indications and inexperience in the techniques [6, 22]. In this study, we showed the value of a

simple and conventional standard nucleotomy. It is suggested that, with appropriate patient selection, good surgical results can be obtained by this procedure, and surgeons are familiar with it.

There are few known reports of long-term follow-up results for standard lumbar nucleotomy [3, 16]. Our results include the success rate, complications, patient satisfaction, and drop-out rate, and our results compare favorably with these studies. We determined that a follow-up of at least 10 years is necessary, since we found the recurrence of disc herniation can occur more than 5 years after

the operation. It was found that the probability of disc herniation relapse declined steadily and was as low as 0.1% per year between 5 and 20 years following surgery. As a result, we believe that an average of 13 years' follow-up is necessary and adequate for long-term follow-up studies of lumbar disc herniation.

In conclusion, we believe that the high value of a standard lumbar nucleotomy after Love should be considered, because of the simple technique and fewer complications, along with the possibility of good results and high patient satisfaction.

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