

# Age - Does it really count? A study of the Perioperative Morbidity and Long-Term Outcome in Patients Above 70 Years of Age Undergoing Spine surgery for Lumbar Degenerative Disorders\*

## *Idade – Deve ser levada em conta? Estudo da morbidade perioperatória e a evolução no longo prazo dos pacientes acima de 70 anos submetidos à cirurgia da coluna vertebral, devido a doenças lombares degenerativas*

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Rev Bras Ortop 2020;55(3):298–303.

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### Abstract

**Objective** To assess the long-term outcome and perioperative morbidity in spine surgeries for lumbar degenerative disorders and, thereby, to evaluate the safety of surgery in the aging population.

**Methods** Retrospective study of patients aged > 70 years, operated for degenerative lumbar disorders between 2011 and 2015. We evaluated patient demographic, clinical and surgical data; comorbidities, perioperative complications, pre & postoperative pain scores and Oswestry disability index (ODI) scores, patient satisfaction and overall mortality.

**Results** A total of 103 patients (Males: Females55:48) with mean age 74.6 years (70–85yrs) were studied. 60 patients (58.2%) had decompression alone, while 43 (41.8%) had decompression & fusion. Mean hospital stay was 5.7days. Mean follow-up was 47.6months (24–73mnths). Patients reported significant improvement in back-pain (Numerical pain score 7.7 vs 1.6;  $p < 0.001$ ), leg pain (Numerical pain score 7.4 vs 1.7;  $p < 0.001$ ), disability (ODI 82.3 vs 19.1;  $p < 0.001$ ) and walking distance ( $p < 0.001$ ). 76% patients were satisfied with the results at the time of final follow-up. 26 patients (25.24%) had perioperative complications which were all minor, without mortality. Most common intraoperative & postoperative complications were dural tear (6.79%) & urinary tract infection (6.79%) respectively.

### Keywords

- ▶ spine surgery
- ▶ intervertebral disc degeneration/ surgery
- ▶ lumbar vertebrae/ surgery
- ▶ elderly

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**Conclusions** With meticulous perioperative care lumbar spine surgery is safe and effective in elderly population. Patients had longer mean hospital stay in view of the gradual and comprehensive rehabilitation program. Presence of comorbidities or minor perioperative complications did not increase the overall morbidity or affect the clinical outcomes of surgery in our study.

## Resumo

**Objetivo** Avaliar o resultado no longo prazo e a morbidade perioperatória em cirurgias da coluna vertebral, devido a doenças lombares degenerativas e, assim, avaliar a segurança da cirurgia na população idosa.

**Métodos** Estudo retrospectivo de pacientes com idade superior a 70 anos, submetidos à cirurgia em virtude de distúrbios lombares degenerativos, entre 2011 e 2015. Foram avaliados os dados demográficos, clínicos e cirúrgicos dos pacientes; comorbidades; complicações perioperatórias; escores de dor no pré e no pós-operatório; índice de incapacidade de Oswestry (ODI, na sigla em inglês); satisfação do paciente e a mortalidade geral.

**Resultados** Foram estudados 103 pacientes (homens:mulheres, 55:48) com idade média de 74,6 anos (70 a 85 anos). 60 pacientes (58,2%) apresentaram somente descompressão, enquanto 43 (41,8%) apresentaram descompressão e fusão. O tempo médio de internação foi de 5,7 dias. O tempo médio de acompanhamento foi de 47,6 meses (24-73 meses). Os pacientes relataram melhora significativa da dor nas costas (pontuação numérica da dor 7,7 versus 1,6;  $p < 0,001$ ), dor nas pernas (pontuação numérica da dor 7,4 versus 1,7;  $p < 0,001$ ), incapacidade (ODI 82,3 versus 19,1;  $p < 0,001$ ) e distância percorrida a pé ( $p < 0,001$ ). Um total de 76% dos pacientes estavam satisfeitos com os resultados no momento do acompanhamento final. 26 pacientes (25,24%) apresentaram complicações perioperatórias, todas sem relevância e sem mortalidade. As complicações intra e pós-operatórias mais comuns foram ruptura dural (6,79%) e infecção do trato urinário (6,79%), respectivamente.

**Conclusões** Com meticulosos cuidados perioperatórios, a cirurgia da coluna lombar é segura e eficaz na população idosa. Os pacientes tiveram um maior tempo médio de internação hospitalar, em virtude do programa de reabilitação gradual e abrangente. A presença de comorbidades ou complicações perioperatórias sem relevância, não aumentou a morbidade geral, nem afetou os resultados clínicos da cirurgia em nosso estudo.

## Palavras-chave

- ▶ cirurgia da coluna
- ▶ degeneração do disco intervertebral/cirurgia
- ▶ vértebras lombares/cirurgia
- ▶ idosos

## Introduction

The proportion of elderly population across the globe had risen from < 1% of world population in 1900 to 6.2% in 1992. It is projected to expand to 20% of the global population by the year 2020.<sup>1</sup> According to the Indian population census, there are nearly 104 million elderly persons (aged 60 years or above) in India. The most common causes of disability amongst the elderly were found to be locomotor and visual.<sup>1</sup> Degenerative lumbar spine disorder is one of the major causes of the locomotor dysfunction, leading to a significant loss of function and inability to perform activities of daily living.

Many of these lumbar degenerative diseases (LDDs) warrant surgical intervention to improve the quality of living of the elderly population. However, significant controversy surrounds the risk-benefit ratio for spine surgeries in this specific group, particularly in view of the existent comorbidities secondary to the aging process. The patients and relatives are often appre-

hensive and concerned about the safety of lumbar spine surgery in the elderly.

A review of the literature demonstrated conflicting results regarding the outcome of the surgical management of LDD in the elderly population.<sup>2-5</sup> With each population demographic having variations in terms of their susceptibility to LDD, the studies and outcome data available from the Indian subcontinent is sparse.

The purpose of the present study was to evaluate the perioperative morbidity and to determine the long-term outcome and satisfaction in patients above 70 years of age undergoing spine surgery for LDD.

## Materials and Methods

### Subject Selection

This was a retrospective study of prospectively collected data of all the consecutive and continuous cases (103 patients) of

lumbar spine surgery, performed between January 2011 and December 2015 for degenerative spinal disorders in patients above of 70 years of age. The approval from the institutional review board (IRB) was obtained. All the surgeries were performed at the authors' institution by the senior author. Patients presenting to the clinic with symptoms of persistent back or leg pain, neurogenic claudication and/or radiculopathy underwent magnetic resonance imaging (MRI) to establish the diagnosis of LDD. Patients who demonstrated other pathologies, such as tumor, trauma, or infection, were excluded from the study. All patients underwent an initial trial of conservative treatment for a period of 6 to 12 weeks. It included analgesics, activity modification, and physical rehabilitation in the form of lumbar and core strengthening programs. At the end of 12 weeks, only those patients with persistent disabling symptoms were offered surgical solution. The decision for the addition of fusion was based on the presence or absence of demonstrable spinal instability. Punjabi<sup>6</sup> radiological criteria was used in the assessment of instability.

All the cases of fusion were instrumented with posterior pedicle screw fixations. Locally harvested autograft from the spinous processes and the lamina were used in all cases. Of the 103 patients, 60 (58.2%) underwent decompression alone, while 43 (41.8%) underwent decompression and fusion. Of the latter, 21.5% patients underwent transforaminal lumbar interbody fusion (TLIF) while 20.3% had posterolateral fusion (PLF).

### Patient Assessment

Patient demographics were recorded and perioperative morbidity assessment was performed for all patients from their charts and medical records. The clinical parameters studied included ASA (American Society of Anesthesiologists) classification of physical status, preoperative medical comorbidities, duration of surgery, perioperative medical and surgical complications and length of hospital stay. The follow-up period ranged from 2 to 6 years (mean 47.6 months). Clinical outcome assessment was done at the final follow-up, upon the conclusion of study (December 2017) through a telephone-based interview. A total of 84 (81.55%) patients were available for the final follow-up: 9 patients had expired due to causes unrelated to the surgery, and 10 patients were lost to follow-up. Patients were asked a predefined set of questions to assess their clinical outcome and satisfaction, and their responses were noted. The outcome measures assessed in the questionnaire included numerical pain scores for back and leg pain, modified Oswestry disability index (ODI), and assessment of ambulatory status. Pain scores were measured using a numerical pain rating scale from 0 to 10. The ODI score was used to evaluate the activities of daily living. The ambulatory status of each patient was assessed by recording the preoperative as well as postoperative distance that the patients could walk before experiencing claudicant or radicular limb pain. Overall subjective patient satisfaction was also recorded by asking the patients whether they were "satisfied" "neither satisfied nor dissatisfied" or "dissatisfied" with the outcomes of surgery. The preoperative clinical

outcome parameters were compared with those obtained at the time of interview at the time of the final follow-up.

### Statistical Analysis

Data analysis was done using the SPSS software version 16.0 (SPSS Inc, Chicago, IL, USA). Data were expressed as range, mean, and/or standard deviation. The Wilcoxon signed ranks test was used for the analysis and comparison of the preoperative and postoperative parameters. Descriptive data were expressed as percentages calculated out of the total.

### Results

The records of 103 patients (55 male and 48 female) were reviewed. The mean age of the study population at the time of surgery was 74.62 years (70–85 years). The mean follow-up after surgery was 47.6 months (24–73months) (►Table 1). Preoperative diagnoses included lumbar canal stenosis (due to ligamentum flavum hypertrophy and facet arthropathy) in 61 patients (59.2%), degenerative spondylolisthesis in 34 patients (33%), and postoperative instability in 8 patients (7.7%). Preoperative neurological deficits were present in 46 patients (44.66%), which included sensory, motor, or a combination of both. The average duration of back pain and leg pain prior to surgery was 11.12 months and 6.51 months, respectively.

A total of 76.6% patients suffered from at least one comorbid condition. The average number of comorbidities per patient was 1.56 (►Table 2). Hypertension (52.4%) was the most common comorbidity, followed by diabetes mellitus, reported in 41.7% patients. A total of 74.2% of patients were on oral hypoglycemic agents, while 25.8% of patients were on insulin. Ischemic heart disease (IHD) was found in 17.4% of patients, 9.2% of whom had undergone angioplasty in the past, while 6.2% underwent coronary artery bypass graft (CABG), and the remaining 2% of patients were managed with the use of medications. All these patients were on anti-platelet drugs, which were stopped 5 days prior to surgery and restarted after surgery from postoperative day 2, once the surgical drain was removed.

Preoperatively, patient physical status was classified as per the ASA classification system (►Table 3) into grades I to VI. The majority of the patients (66%) were classified as ASA grade III, while 27.3% and 6.7% of the patients fell in grade III and grade I, respectively.

The average duration of surgery was 136.94 minutes. As anticipated, the duration of the decompression-only group

**Table 1** Demographic data on the 103 elderly patients who underwent surgery

Mean Age	74.62
Sex (male/female)	55/48
ASA (I/II/III)	6.7%; 66%; 27.3%
Average follow-up	47.6 months
Deaths (at time of final follow-up)	9

Abbreviation: ASA, American Society of Anesthesiologists.

**Table 2** Distribution of comorbidities

Comorbidity	Number of patients
Hypertension	54
Diabetes	43
Ischemic heart disease	18
Asthma/COPD	7
Thyroid dysfunction	6
Chronic kidney disease	4
Parkinsonism	4
Tuberculosis	4
Malignancy	3
Rheumatoid arthritis	1
Ankylosing spondylitis	1
Depression	1

Abbreviation: COPD, chronic obstructive pulmonary disease.

**Table 3** American Society of Anesthesiologists classification of physical status

Class	Definition
I	No systemic disease
II	Mild to moderate systemic disease
III	Severe systemic disease
IV	Severe systemic disease that is life threatening
V	Moribund patient with little chance of survival

was lower (120.4 minutes) as compared with the fusion group (144.6 minutes). Within the fusion group, TLIF was more time consuming as compared with PLF (159.1 minutes vs 130.2 minutes, respectively). Blood loss during the surgery averaged 346.6 ml, and it was higher for the fixation group than for the decompression-only group (396.2 ml vs 306.3 ml, respectively). Transfusion was required perioperatively in 14 patients (13.5%), who had an average intraoperative blood loss of 804.16 ml. Postoperatively, intensive care unit (ICU) stay was needed for 7 patients (6.75%): 2 patients had developed cardiac dysrhythmia postoperatively, 1 developed had acute cholecystitis, while 4 patients who had prior history of cardiac ailments with poor cardiac reserve, were kept in the ICU for monitoring and observation.

Overall, perioperative complications were noted in 26 of the 103 operated patients (25.24%). Nine patients (8.73%) had intraoperative complications: dural injury in 7 patients (6.79%), and hypotension and arrhythmia in 2 patients (1.94%). Of the seven patients with incidental dural tear, four were undergoing revision spine surgery, having a previous spine surgery performed at the same/adjacent level. Dural leak was sealed with autologous fat graft. Primary dural repair was not done in any of the cases. All patients had a subfascial drain inserted, which were kept uncharged. Patients were kept on strict bed rest for 3–5 days, until no evidence of cerebrospinal fluid (CSF) was seen in the drain,

**Table 4** Perioperative complications

Complications	Number (%)
Dural tear	7 (6.79%)
Surgical site infection	3 (2.91%)
Urinary tract infection	7 (6.79%)
Altered sensorium	3 (2.91%)
Nausea/vomiting	3 (2.91%)
Hypotension/arrhythmia	2 (1.94%)
Acute cholecystitis	1 (0.97%)
Total	26 (25.24%)

following which they were gradually mobilized and the drain subsequently removed. No residual complications relating to dural leak were noted. Postoperative complications were observed in 18.4% patients, medical complications in 15.5% while surgical complications in 2.91%. Urinary tract infection (6.79%) was the most common medical complication followed by dyselectrolytemia and altered sensorium (2.91%) and recurrent vomiting (2.91%) (→ **Table 4**). Superficial surgical wound infection occurred in three patients (2.91%). All cases were treated with prolonged antibiotics and periodic wound dressing. Though the wound healing was delayed, none of these cases required secondary debridement or re-suturing. No perioperative mortality or any life-threatening complications were recorded in our study.

Presence of medical comorbidities was not a direct cause of surgical or medical complications in any of our patients. On comparative subgroup analysis, we observed that there was no increase in the percentage of complications in patients belonging to the higher ASA grades when compared with those with the lower ASA grades (→ **Table 5**), thereby making ASA a less reliable outcome measure for predicting postoperative complications.

The average duration of hospital stay was 5.69 days. The duration of hospital stay was prolonged as the elderly patients could not tolerate aggressive physical therapy, unlike in the younger population. Hence gradual physiotherapy, starting with in bed exercises, progressing to mobilization with walker and ultimately making them capable and confident of independent mobilization was done. All the patients were discharged to their respective homes, none of the patients were discharged to any nursing homes or rehabilitation centers or outpatient care units.

Stay was longer in patients undergoing decompression and fusion (6.16 days) when compared with patients undergoing decompression-alone (5.35 days). For the patients who had incidental iatrogenic dural tear intraoperatively, the length of hospital stay was prolonged to a mean 8.71 days. Owing to deaths and unwillingness to participate, only 84 (81.55%) patients were available for final follow-up assessment of clinical outcomes. Preoperatively, patient reported mean numerical pain scores for leg pain and back pain were  $7.37 \pm 0.9$  and  $7.6 \pm 0.8$  respectively. The mean numerical

**Table 5** Distribution of complications relevant to the American Society of Anesthesiologists

ASA	I	II	III
Number of patients	7	68	28
Complications			
Dural tear	0	6	1
Surgical site infection	0	2	1
Urinary tract infection	2	4	1
Altered sensorium	0	2	1
Vomiting	1	1	1
Hypotension/arrythmia	0	1	1
Acute cholecystitis	0	1	0
Total number of complications	3 (42%)	17 (25%)	6 (21.4%)

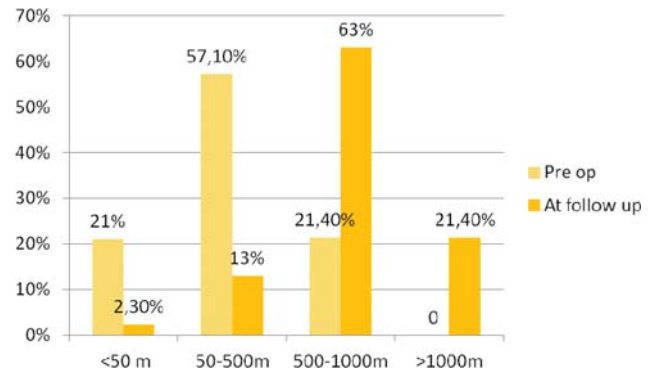
Abbreviation: ASA, American Society of Anesthesiologists.

pain scores fell to  $1.57 \pm 1.7$  and  $1.56 \pm 1.9$  respectively at final follow-up after surgery, suggestive of significant improvement ( $p < 0.0001$ ) (**Table 6**). Mean ODI score improved from 82.32% preoperatively to 19.17% at final follow-up, a highly significant improvement ( $p < 0.0001$ ) (**Table 6**). The ambulatory status of 84.52% patients had improved by at least one grade from the preoperative value, at the time of the final follow-up (**Fig. 1**). At follow-up, 76% of patients were satisfied with the surgery, while 13% of patients were dissatisfied. 11% of patients were neither satisfied nor dissatisfied.

At the time of the final follow-up, 9 patients had died due to causes unrelated to surgery, with the mean duration between surgery and death being 45.1 months. However, no patients died in the immediate (< 3 months) postoperative period. None of the patients required revision lumbar spine surgery until the time of mean follow-up of 47.6 months.

**Discussion**

With the significant advancement in modern medicine, the life expectancy of the population around the world is on the rise. Aging and degeneration go hand in hand, leading to an increase in the number of degenerative lumbar spine dis-



**Fig. 1** Walking distance of patients preoperatively and at the time of final follow up postoperatively.

orders, many of them warranting surgical treatment. This retrospective study investigated 103 consecutive cases of patients above 70 years of age with lumbar degenerative disorders who underwent spine surgery. The overall perioperative morbidity, long-term clinical outcome as well as patient satisfaction were favorable in this study population.

The comorbidity pattern in our study was comparable with those reported by Ragab et al<sup>5</sup> and Shabat et al.<sup>7</sup> Neither the presence of comorbidities nor the ASA class of patients had any bearing on the incidence of perioperative complications or the overall outcome.

While no major complications were noted, minor complications related to surgery were found in 25.24% of patients. Ragab et al,<sup>5</sup> in their study of 118 patients (mean age of 74 years and average follow-up of 84 months) undergoing lumbar spine surgeries, reported a complication rate of 20%.

Four out of the seven patients with dural tear in our study were undergoing revision spine surgery. Smorgick et al<sup>8</sup> noted a significantly higher incidence of dural tear in revision spine surgery (29/116 patients; 25%). Narrower canal, thicker flavum, osteophyte formation, redundant dura due to degenerative spinal settling and increased dural friability have been described as the predisposing factors leading to increased incidence of dural tear in the elderly population according to Yoshihara and Yoneoka.<sup>9</sup>

Analyzing the data of the octogenarian population from the Spine Patient Outcomes Research Trial (SPORT), the authors concluded that there was no significant increase in the complication and mortality following surgery in this subset of population.<sup>10</sup>

**Table 6** Clinical outcome measures

	Preoperatively		At final follow-up		Significance
	Mean	Standard deviation	Mean	Standard deviation	
Numerical pain scale (leg pain)	7.37	0.889	1.57	1.765	$p$ -value < 0.0001
Numerical pain scale (back pain)	7.60	0.823	1.56	1.922	$p$ -value < 0.0001
ODI score	82.32	5.764	19.17	24.14	$p$ -value < 0.0001

Abbreviation: ODI, Oswestry disability index.



There was no significant difference in the complication rates between the decompression-only and fusion groups in our study. Lee et al, in a review of the literature, did not note any negative effect on clinical outcomes by the addition of fusion to the decompression surgery in spinal stenosis.<sup>11</sup>

Perioperative mortality rate of 0.6 to 1.3% has been reported following lumbar spine surgery.<sup>5,12</sup> No perioperative deaths were noted in the current study. Lee et al<sup>11</sup> reviewed the literature on outcomes of lumbar spine surgery in geriatric patients and noted that there was no significant rise in mortality in individuals undergoing surgery as compared with age-matched controls who did not undergo the same.

In our study, the mean duration of hospital stay was 5.69 days, being slightly higher in those having fusion as compared with those who underwent decompression alone. The findings in our study were comparable to those of Ragab et al,<sup>5</sup> who noted an average hospital stay of 4 days and 6 days in the decompression and fusion groups, respectively.

Patients described significant reduction of their back pain and leg pain, improvement in their ambulatory capacity and ODI score. Ragab et al,<sup>5</sup> in their study of 118 patients with a mean age of 74 years, reported an overall patient satisfaction in 68%, while Shabat et al<sup>7</sup> reported 76% satisfaction rate, when studying the outcomes of 39 patients above 80 years of age with lumbar spine stenosis. In our study, 76% of patients reported that they were satisfied with the surgical results.

It is important to bring a distinction between the chronological age and the functional age of the elderly, and, thereby, to challenge the conventional belief of age being an exclusion criterium for lumbar spine surgery. Age is not a contraindication to lumbar spine surgery, neither is it a harbinger for a catastrophic complicating event in patients undergoing surgery. However, careful monitoring and increased vigilance toward occurrence of any untoward minor perioperative complication is warranted in this subset of high-risk population.<sup>13,14</sup>

The retrospective design of the study is the primary limitation of this analysis. Since the perioperative data of the patients are noted from the data record charts, certain minor unrecorded events or complications may have been missed. Additionally, the lack of a comparative cohort of patients under 75 years of age precluded comparative cohort analysis. Use of telephone interview as the method for follow-up is also a limitation in the study. Direct patient follow-up was not possible in these geriatric patient population due to issues related to the travel to the hospital.

## Conclusion

With careful patient selection and meticulous perioperative care, lumbar spine surgery is safe and effective in the elderly population who fail to respond to conservative measures.

Patients had longer mean hospital stay in view of the gradual and comprehensive rehabilitation program. Presence of comorbidities or minor perioperative complications did not increase the overall morbidity or affect the clinical outcomes of surgery in our study. Age, per se, does not predict the outcome of lumbar spine surgeries, and therefore should not be used as the sole criterion in the surgical decision-making process.

## Conflict of Interests

The authors declare that have no conflict of interests.

## References

- 1 Central Statistics Office. Ministry of Statistics and Programme implementation, Government of India. Elderly in India 2016. Disponivel em: [mospi.nic.in/sites/default/files/.../ElderlyinIndia\\_2016.pdf](http://mospi.nic.in/sites/default/files/.../ElderlyinIndia_2016.pdf)
- 2 Katz JN, Lipson SJ, Larson MG, McInnes JM, Fossel AH, Liang MH. The outcome of decompressive laminectomy for degenerative lumbar stenosis. *J Bone Joint Surg Am* 1991;73(06):809-816
- 3 Esses SI, Huler RJ. Indications for lumbar spine fusion in the adult. *Clin Orthop Relat Res* 1992;(279):87-100
- 4 Sanderson PL, Wood PL. Surgery for lumbar spinal stenosis in old people. *J Bone Joint Surg Br* 1993;75(03):393-397
- 5 Ragab AA, Fye MA, Bohlman HH. Surgery of the lumbar spine for spinal stenosis in 118 patients 70 years of age or older. *Spine* 2003;28(04):348-353
- 6 Panjabi MM. Clinical spinal instability and low back pain. *J Electromyogr Kinesiol* 2003;13(04):371-379
- 7 Shabat S, Arinzon Z, Folman Y, et al. Long-term outcome of decompressive surgery for lumbar spinal stenosis in octogenarians. *Eur Spine J* 2008;17(02):193-198
- 8 Smorgick Y, Baker KC, Herkowitz H, et al. Predisposing factors for dural tear in patients undergoing lumbar spine surgery. *J Neurosurg Spine* 2015;22(05):483-486
- 9 Yoshihara H, Yoneoka D. Incidental dural tear in spine surgery: analysis of a nationwide database. *Eur Spine J* 2014;23(02):389-394
- 10 Rihn JA, Hilibrand AS, Zhao W, et al. Effectiveness of surgery for lumbar stenosis and degenerative spondylolisthesis in the octogenarian population: analysis of the Spine Patient Outcomes Research Trial (SPORT) data. *J Bone Joint Surg Am* 2015;97(03):177-185
- 11 Lee JY, Moon SH, Suh BK, Yang MH, Park MS. Outcome and Complications in Surgical Treatment of Lumbar Stenosis or Spondylolisthesis in Geriatric Patients. *Yonsei Med J* 2015;56(05):1199-1205
- 12 Oldridge NB, Yuan Z, Stoll JE, Rimm AR. Lumbar spine surgery and mortality among Medicare beneficiaries, 1986. *Am J Public Health* 1994;84(08):1292-1298
- 13 Jakola AS, Sørliie A, Gulati S, Nygaard OP, Lydersen S, Solberg T. Clinical outcomes and safety assessment in elderly patients undergoing decompressive laminectomy for lumbar spinal stenosis: a prospective study. *BMC Surg* 2010;10:34
- 14 Arinzon ZH, Fredman B, Zohar E, et al. Surgical management of spinal stenosis: a comparison of immediate and long term outcome in two geriatric patient populations. *Arch Gerontol Geriatr* 2003;36(03):273-279