Submitted: 10 August, 2021 Accepted: 24 September, 2021 Published: 08 November, 2022 DOI:10.22514/sv.2022.022

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ORIGINAL RESEARCH

Quality of life in osteoporotic patients with low-grade degenerative spondylolisthesis

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Abstract

Degenerative spondylolisthesis (DS) and osteoporosis (Op) are two complex diseases affecting the spine in the general population over the age of 50 years and can cause an accumulating clinical-dysfunctional impact that ultimately impacts on quality of life. The aim of the present study is to investigate whether our rehabilitation program relieves pain and restores physical function and quality of life in 52 females with postmenopausal Op and DS with a degree of slip ranging from 5%–25%, Meyerding grade I, during a six-month period. All patients were randomized (Study group—25 patients, Control group—27 patients) and completely assessed. Functional parameters were measured at admission to inpatient rehabilitation (T1), after 4 weeks (T2), and 6 months (T3) following the commencement of rehabilitation. We used student's *t*-test to compare the study and control groups for each variable measured and each time, and ANOVA (Analysis of variance) to compare the three sets of result obtained for each measured variable over time. The values for VAS (Visual Analogue Scale), SRM (Roland-Morris Disability Questionnaire) and SF-MOS (Medical Outcomes Study Questionnaire Short Form 36 Health Survey) improved in a highly significant manner over the duration of the study, both for the study and control groups. The results confirmed the complexity in the level of functionality and the results had no statistical significance in the T2 and T3 assessment. The effectiveness of the rehabilitation program for the study group was supported by the development of the differences between VAS and SRM. We found that non-surgical care and rehabilitation program is one of the optimal choices for osteoporotic patients with minimal DS, especially after 60 years of age.

Keywords

Degenerative spondylolisthesis; Postmenopausal osteoporosis; Rehabilitation program

1. Introduction

Degenerative spondylolisthesis (DS) and osteoporosis (Op) are two complex diseases that affect the spine in people over 50, with a clinical-dysfunctional impact that is cumulative and impactful on quality of life.

Degenerative spondylolisthesis is one of the five categories of spondylolisthesis (SD), defined as a segmental destabilization in the low lumbar spine associated with many multifactorial degenerative changes [1]. As a pathological condition, DS has traditionally been considered to represent a classic example of instability of the vertebral segment [2], due to the non-traumatic slipping of a vertebral body, in relation to the vertebra located immediately caudal, following degenerative changes of the spine (progressive degeneration of the facet joints and the intervertebral discs with aging) [3], with no pars interarticularis defect (spondylolysis) and with no associated defect or disruption in the vertebral ring [4]. The prevalence of all types of lumbar SD has been estimated to be approximately 4% to 8% in the general population [5] but it increases with age [6], and women are approximately three times more likely to be affected than men [7]. The prevalence of DS is very age and gender-specific: below 50 years of age, there is a low incidence of DS for all people; after 50 years, its prevalence increases, but women tend to develop DS at a faster rate than men [8] (ranging from 14%–30%) [6]. The female: male prevalence ratio for DS is estimated to be approximately 1.3:1 [7], but these values are more difficult to confirm in other studies [8–10].

Before the age of 50 years, DS is rare but the incidence in postmenopausal women is higher than in age-matched men, therefore, the association between the menopause and DS was proposed [11, 12].

Four years ago, it was suggested that hormone replacement therapy may alleviate the development of DS in postmenopausal women [8]. Furthermore, lumbar SD is an independent risk factor for vertebral compression fractures in patients with Op [13] and therefore, patients with Op and DS require greater attention. Like DS, the incidence of Op

has increased with the emergence of an aging population. Osteoporotic women have back pain (thoracic and lumbar) and limited mobility as a clinical expression of osteoporotic vertebral compression fracture (VCF), representing one of the major complications of this complex bone disorder [13]. Although these women have various dysfunctions with severe impact on the activity of daily living (ADLs) and independent lifestyle, approximately one third of osteoporotic VCFs receive clinical attention [14]. In recent years Op has become a public health problem and is considered a true "silent epidemic", because of the increase in the number of Op fractures in the world as a result of an increased population in the 3rd age group and an increase in life expectancy while reducing physical effort [15]. Reduction of bone mass and osteoporotic fractures creates specific challenges that cannot be met with pharmacotherapy alone [16]. Physical rehabilitative measures play a key role after fracture and beyond, for the prevention of further fracture, including VCFs [17].

In the literature, only a few studies have mentioned a significant association between VCFs and SD in older patients. Patients whose vertebral body have slipped over the underlying vertebra are at an increased risk of vertebral fractures when compared to patients with no SD after Op [13]. Importantly therefore, early detection of SD in osteoporotic patients has become an important clinical requirement. In the early stages, both DS patients and those with Op may be asymptomatic and the rehabilitation program is selected in accordance with clinical and functional individual status. Furthermore, different treatment plans are selected for different disease periods and no consensus can be reached on the role of nonoperative versus surgical care because of limited investigations and heterogeneity of studies reported [18].

The aim of the present study is therefore, to investigate whether the rehabilitation program relieves pain and restores physical function and quality of life in females with postmenopausal Op and DS with a degree of slip ranging from 5%–25%, and with a Meyerding grade I, during a six months period.

2. Materials and Methods

2.1 Design

We conducted a single-blinded randomized controlled trial (Fig. 1) during the period January 2019–February 2020 in the rehabilitation departments of the University of Medicine and Pharmacy, Craiova, Romania. Fifty two osteoporotic females with lumbar DS were randomly including in two groups (study group—SG and control group—CG), and were homogeneous in terms of biographical and disease features.

The inclusion criteria considered when designing the groups were:

- Patients older than 55 years of age, known to have postmenopausal Op and recently diagnosed with DS.
- Absence of other significant lower limb osteoarthritis.
- Patients with stable cardiovascular and respiratory function, with normal blood pressure and with no unstable medical conditions.

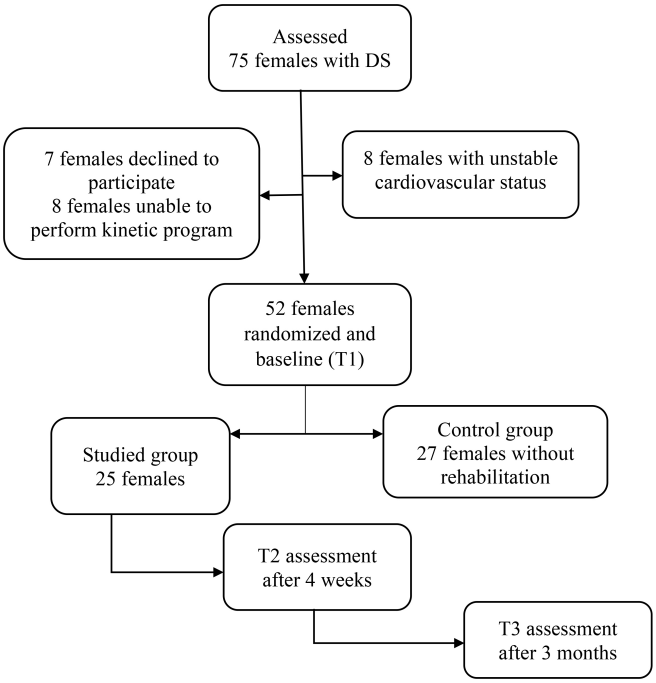

FIGURE 1. Diagram of our study. DS: Degenerative spondylolisthesis.

- Compliance with physical exercise during the healthcare program.

We performed patient randomization via a computer-generated list. Only the physical therapist was aware of the group allocation of each subject. The other members of the rehabilitation team and the patients had no information concerning the randomization and we respected the Recommendation for Interventional Trials (SPIRIT) guidelines [19].

2.2 Patient assessment

We completed an initial clinical, laboratory and functional assessment which included:

- General physical examination.
- Musculoskeletal examination—somatoscopic exam, systematic palpation of all areas of the vertebral column, assessment of the range of motion, tenderness and stability and manual muscle testing of the trunk and lower limb muscles.
- Examination of balance and gait.

During the examination, we conducted standard laboratory tests and radiological examinations of the lumbar column (Fig. 2. Lumbar spine-lateral incidence). We used the Wiltse-Newman classification of SD [20].

All 52 females underwent dual energy X-ray absorptiometry (DXA) for the determination of actual level of bone mineral density of the lumbar spine, using a stratos densitometer. The standard anteroposterior L1–L4 scanning permitted the establishment of a T-score for each vertebra and a total T-score (Table 1).

TABLE 1. The data of the patients.

Variable	Study Group (SG)	Control Group (CG)	*p* Student
Mean age (years)	62.88 ± 5.01	63.78 ± 3.91	0.4727
Patients' gender	Females		
Duration of Op (years)	5.72 ± 1.62	5.93 ± 1.44	0.6296
% displacement	10.40 ± 3.64	10.70 ± 3.54	0.7616
Comorbidities	no	no	
Drugs assumption	Analgesic—twice daily, 3–5 days		
	Naproxen twice daily, 5–7 days		
	Vitamin D–1000 international units/daily		
	150 mg acid ibandronicum montly		
Concomitant spine disease	Spondylosis	Spondylosis	
History of spine surgery	no	no	
T Score			
L1	2.48 ± 0.36	2.42 ± 0.33	0.9876
L2	3.04 ± 0.39	3.00 ± 0.36	0.6674
L3	2.87 ± 0.38	2.82 ± 0.31	0.6289
L4	2.07 ± 0.32	2.01 ± 0.31	0.5165
Total Tscore	2.92 ± 0.25	2.86 ± 0.22	0.9152
Z score	0.96 ± 0.25	0.91 ± 0.25	0.4404
VAS1	4.88 ± 0.78	4.78 ± 0.85	0.6538
VAS3	3.16 ± 0.69	4.22 ± 0.89	<0.0001
SRM1	8.76 ± 1.23	8.96 ± 1.19	0.5492
SRM2	5.40 ± 0.65	7.41 ± 1.19	<0.0001
SRM3	4.80 ± 0.87	6.37 ± 0.84	<0.0001
SF-MOS1	53.88 ± 8.05	59.52 ± 11.11	0.0425
SF-MOS2	63.96 ± 7.59	66.41 ± 9.85	0.3232
SF-MOS3	69.80 ± 6.26	71.26 ± 8.53	0.4881

VAS—Visual Analogue Scale; SRM—Roland-Morris Disability Questionnaire; SF-MOS—Medical, Outcomes Study Questionnaire Short Form 36 Health Survey.

For the functional assessment, we used:

- The VAS—Visual Analogue Scale (from 0 to 10, 0 = absence of pain and 10 = maximum pain score, other values between 0 and 10 were directly proportional to the intensity of pain, depending on the individual pain threshold).
- The Roland-Morris Disability Questionnaire (SRM)—a self-administered disability measure in which greater levels of disability are reflected by higher numbers on a 24-point scale [21].
- The Medical Outcomes Study Questionnaire Short Form 36 Health Survey (SF-MOS)—an indicator of overall health status, has eight scaled scores ranging from 0–100; lower scores = more disability, higher scores = less disability [22].

Outcomes for VAS, SRM and SF-MOS scores were measured at admission to inpatient rehabilitation (T1), after 4 weeks (T2), and 6 months (T3) following the commencement of rehabilitation. These time points were chosen to adequately measure the rate of improvement in all outcome measures (mentioned in Table 1).

2.3 Patient rehabilitation

The rehabilitation program was performed in the two following phases:

- Inpatient period: when patients had the ability to perform some kinetic tasks (mentioned in Table 2) we considered were able to be discharge from hospital.
- Home-based program with bimonthly supervision.

The healthcare objectives were adapted for all patients and rehabilitation phases:

- Painful status control.
- Restoring, as much as possible, vertebral spine function.
- Regaining motor control.
- Enhancing quality of life.

TABLE 2. Kinetic program for inpatient rehabilitation program.

Components of the kinetic program applied between T1 and T2 evaluation period	
Objective	Rehabilitation components/Intermediate Exercise Program
Diminish pain	Posture—resting and avoiding movements like lifting, bending
Increase	Stretching—the erector spine, gluteal and hamstrings muscles
flexibility muscles	Each exercise—20 seconds, repeated 3 times for each side
Improve muscular endurance and strength	
	Multifidus Activation—5 times/session, twice a day
	Quadruped Arm and Leg Raise—for abdomen hip flexors, glutes, and spine—5 times/session, twice a day
	Strengthening of the deep abdominal muscles—daily, in antigravity position, 2 sets, 10 repetitions/set, 2 minutes' rest between sets
	Elastic band exercises (lying position)—5 time/session, twice a day
Maximize patients' coordination (core stability) Return to functional activities	
	Knee to chest—15 seconds, repeated 3 times/day
	Pelvic tilt—performed 10 times/1 session/day
	Ambulation with use of an assistive device
	Ascend and descend stairs, with assistive device
	Walking in all variations—tandem walking, lateral stepping over/around objects, front and lateral step-ups
	Coordinative skills—Frenkel exercises 1 session/day

Rehabilitation program was complex and included:

- Pharmacological measures—analgesics, anti-inflammatory drugs, vitamin D and oral bisphosphonates, for the improvement of Bone Mineral Density (BMD) and bone microarchitecture [23].
- Non-pharmacological measures—educational (activities involving heavy lifting are prohibited), dietary with optimal sources for calcium, posture and bracing, physical (magneto therapy, transcutaneous electrical nerve stimulation—TENS and low laser therapy—LLT for paravertebral and hip girdle muscles), massage and kinetic measures.

All patients from SG performed exercises to combat pain, and increase flexibility and endurance of the trunk muscles and return to functional daily activities. Each exercise session was supervised and performed twice daily, 5 days/week, 3 weeks. The a.m. kinetic program (5 minutes warm-up, 20 minutes flexibility and strength exercises, 5 minutes cool-down) was preceded by TENS and LLT, and the p.m. kinetic program (5 minutes warm-up, exercises for return to functional activities, 5 minutes cool-down) was preceded by 20 minutes of magneto therapy. Between exercise programs, SG patients used a thoraco-lumbar brace, to reduce the load on the lumbar spine.

2.4 Statistic data

Data were recorded using Microsoft excel files; statistical analyses were performed using MS excel (Microsoft Corp., Redmond, WA, USA), together with the XLSTAT (Version 14, Addinsoft SARL, Paris, France). add-on for MS excel (Addinsoft SARL, Paris, France). Descriptive analysis of the study groups was performed with MS excel. Statistical tests (Student's *t*-test and ANOVA) were performed using the XLSTAT addon.

We used Student's *t*-test to compare study and control groups for each measured variable and each time, and ANOVA to compare the three sets of results obtained for each measured variable over time.

3. Results

We studied osteoporotic females, with the only demographic factors examined being age and duration of the menopausal period.

Only one vertebral level was involved in our osteoporotic patients (L4–L5), and the percent of slip ranged from 5%–13%, representing Meyerding grade I slip.

All patients in the SG performed the rehabilitation program, which was possible due to the lack of progression of L4–L5 DS. The conservative management of all patients were performed due to their clinical and functional status. Moreover, the possibility of surgery was not accepted by any patient.

By examining the DXA, we found that the lumbar vertebrae (L1–L4) had a level below the defined osteoporotic threshold. The mean values did not correlate significantly with any of the parameters studied. The L2 vertebra had the lowest value of bone mineral density (–3 DS in SG and –3.04 in CG, both negative values for T-score). It is well known that the biomechanics of the lumbar region is multi conditional. When the two vertebral degenerative entities (Op and DS) are associated, females had various dysfunctional experiences.

We found no statistically significant difference in BMD of all the lumbar vertebrae between patients and controls, even though it was lower in the patient group. According to the World Health Organization, all females have 2.5 standard deviations below the typical bone mass of young healthy white

FIGURE 2. Lumbar spine-lateral incidence. 7 mm DS L4–L5 with the thought of the disk space. Mild lumbar scoliosis. Accentuation of lumbar lordosis. Posterior interopophyseal osteoarthritis L4–L5, L5–S1.

women at L2 and L3. As a result, a biomechanical stress on L4 vertebra was above normal and added to the local degenerative condition.

The values for VAS, SRM and SF-MOS improved in a highly significant manner over the duration of the study, both for the study and control groups (mentioned in Table 3 and the diagrams in Fig. 3). There were no significant differences in the variables that describe the clinical state of the patients, so we can conclude that the two groups were similar at the beginning of the study. Initial values (T1) of pain parameters (VAS and SRM) were similar, but the final values (T3) in the study group decreased significantly more than in the control group, even after intermediate monitoring (T2) for SRM. Initial SF-MOS values (T1) were significantly higher in the control group, but they became similar, since the intermediate monitoring. (Fig. 3A).

Using Student's *t*-test, we demonstrated that there was a highly significant difference between the values of the study parameters (VAS, SRM and SF-MOS) from the subjects in the study group and those in the control group; those in the study group having higher average values than the other group for VAS ($p = 0.00000079$, <0.001) and SRM ($p = 0.000016$, <0.001), but lower than the others ($p = 0.000000014$, <0.001) for SF-MOS (Fig. 3B).

The effectiveness of the rehabilitation program for the study group was supported by the development of the differences between VAS and SRM.

Physical activity and functional levels of our patients were quantified with SF-MOS and the results confirmed the complexity of the level of functionality, but these results were not statistically significant in the T2 and T3 assessment.

4. Discussions

Our study was performed in accordance with the worldwide research on quality of life and healthy ageing with evaluation and implementation of medical interventions to promote an unbiased and integrated system for long-term care [24].

We investigated only female patients because Op and DS are more common in women than men, especially after age 50.

The number of people aged 60 years and older however, is rapidly increasing worldwide, from 1 billion in 2019 to 1.4 billion by the end of the *Decade of Healthy Ageing* (2020–2030), and this also simultaneously increases cases of degenerative diseases of the spine such as Op with vertebral compression fractures, intervertebral disk protrusion, SD and spinal canal stenosis [25]. Moreover, the prevalence of Op is highest in female patients along with DS [26].

There are few studies in the literature assessing, conservative treatments and rehabilitation for osteoporotic patients with grade I DS, as most address different surgical modalities.

4.1 Pathogenic assessment

Both Op and DS are skeletal disorders, having the potential for mutual pathogenic conditioning. Decreased structural strength of the bone in Op [16] can exceed the ability of vertebrae to carry a seemingly normal load and favors the abnormal biomechanical requests (micro architectural deterioration of bone tissue, bone remodeling, increased risk of fracture, degree of wear of facet joints). This process is accelerated by vertebral osteoarthritis [27], accelerated degeneration of discs and disc space narrowing [28] and general laxity of the paraspinal ligaments [27]. All these aspects are in accordance with the conclusion of a 2017 systematic review—role of the menopause as a trigger for accelerated DS development after the immediate postmenopausal phase in women [8]. Probably, inactivity in DS patients with more severe pain, leading to a larger bone loss, but the specific role of bone mineral density in lumbar degenerative disease is not very well understood [29].

In osteoporotic females, DS generated abnormal loading is a greater challenge for dynamic stabilization [30]. Two main biomechanical reasons might explain the relationship between SD and the risk of vertebral osteoporotic fractures in postmenopausal females. First, SD might be associated with an increased lumbar lordosis or thoracic kyphosis, an independent risk factor for vertebral osteoporotic fractures [31]. Second, kyphosis posture and age could lead to a sagittal imbalance of the spine [32] with compromised trunk muscle activation, leading to falls and vertebral osteoporotic fractures.

The physiological thoracic kyphosis and increased stresses

TABLE 3. Mean values of studied parameters in all patients.

Variable	Group	Initial	Intermediate	Final	*p* ANOVA
VAS					
	Study				
		4.88 ± 0.78	-	3.16 ± 0.69	0.0000
		C.V. (%) = 16.00%	-	C.V. (%) = 21.77%	
	Control				
		4.78 ± 0.85	-	4.22 ± 0.89	0.0228
		C.V. (%) = 17.73%	-	C.V. (%) = 21.12%	
		p student = 0.654	-	*p* student = 0.000	
		Dif VAS	SG = 1.72 ± 0.46	CG = 0.56 ± 0.64	<0.0001
SRM					
	Study				
		8.76 ± 1.23	5.40 ± 0.65	4.80 ± 0.87	0.0000
		C.V. (%) = 14.09%	C.V. (%) = 11.95%	C.V. (%) = 18.04%	
	Control				
		8.96 ± 1.19	7.41 ± 1.19	6.37 ± 0.84	0.0000
		C.V. (%) = 13.30%	C.V. (%) = 16.00%	C.V. (%) = 13.17%	
		p student = 0.549	p student = 0.000	*p* student = 0.000	
		Dif SRM	SG = 3.96 ± 1.57	CG = 2.59 ± 0.93	0.0003
SF-MOS					
	Study				
		53.88 ± 8.05	63.96 ± 7.59	69.80 ± 6.26	0.0000
		C.V. (%) = 14.94%	C.V. (%) = 11.86%	C.V. (%) = 8.97%	
	Control				
		59.52 ± 11.11	66.41 ± 9.85	71.26 ± 8.53	0.0002
		C.V. (%) = 18.66%	C.V. (%) = 14.84%	C.V. (%) = 11.97%	
		p student = 0.043	*p* student = 0.323	*p* student = 0.488	
		Dif SF-MOS	SG = 15.92 ± 5.45	CG = 11.74 ± 7.19	0.0229

VAS—Visual Analogue Scale, SRM—Roland-Morris Disability Questionnaire, SF-MOS—medical outcomesstudy questionnaire short form 36 health survey, C.V.—coefficient of variation, Dif—difference.

at the anterior margins of the thoracic vertebral bodies in osteoporotic spines produce prominent wedging of the mid-thoracic vertebrae, subsequently exacerbating hyperkyphosis by anterior translation of the head and upper torso [33]. However, grade I DS is less associated with balance deficits, which is similar to our findings. Probably, pelvic parameters, especially muscular strength, are involved in compensatory mechanisms [14].

Here, we have proven that the kinetic program has a real role in pain reduction. We performed muscle strengthening exercises for spinal stabilisation which ensure the maintainance of neutral pelvic alignment causing force transfer and thereby decreasing the amount of load to the area. In females with Op and DS, we have to pay more attention to the transverse abdominis and multifidus; their co-contractions provide a balanced effect on the spine. Kinetic programs including exercises for hamstrings and gluteal mucles is important to incorporate ergonomic movements into patient daily activities and the results were justified by the VAS and SRM values. We remarked a patient compliance for bracing, especially after we explained its benefical role for posture and movement pattern assistance of the spine. Therefore, patients were tought how to the keep spine safe. Moreover, in the rehabilitation programs, physical therapy measures allowed optimal pain control through the control of sympathetic vegetative tone, reducing muscle spasms, and increasing the production of endorphins, the natural pain killers.

4.2 Clinical and functional assessment

All females studied complained of symptoms that defined a clinical status allowing conservative treatment—dorsal and lumbar pain (exacerbated by repetitive rotation, and relieved by resting), intermittent unilateral radiculopathy weakness in the legs, numbness in lower extremities, similar to other studies [34, 35].

Various limitations of physical function and daily activities were explained by vertebral mal-alignment, due to os-

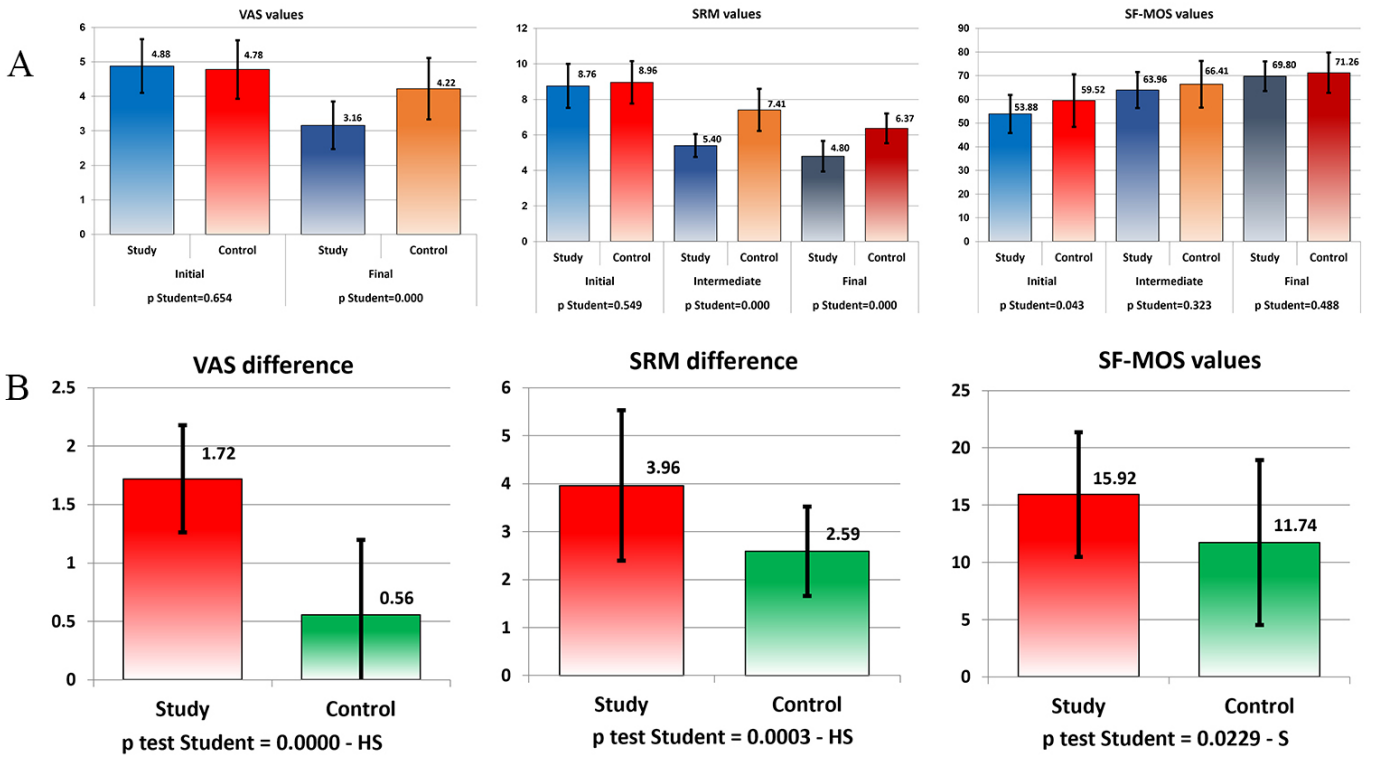

FIGURE 3. Initial values of pain parameters (VAS and SRM) were similar, but the final values in the study group decreased significantly more than in the control group. (A) Initial SF-MOS values were significantly higher in the control group, but they became similar, even since intermediate monitoring. (B) There is a highly significant difference between the values of the studied parameters (VAS, SRM and SF-MOS) of the subjects in the study group and those in the control group—performing the student's *t* test.

teoporotic fractures [36] and minimal L4–L5 lysthesis. The mean values of the study scales (SRM and SF-MOS) defined a minimal to moderate dysfunction of the lower limb. The mean values of the function scale scores after the rehabilitation program sustained this improved level in patient quality of life. Thus, the treatment began with conservative care, without surgical stabilization, with more thread than not exist a universal agreement regarding the optimal surgical approach for the treatment of degenerative SD in osteoporotic patients [37]. We realized that Op has become one of the most prevalent public-health concerns and a major medical problem [38].

4.3 Imaging assessment

Our patients were diagnosed with L4–L5 grade I DS, the most frequent form of SD, since the last decade [29, 39].

All studies found that grade I DS, was typically found at the L4–L5 level, followed by L3–L4 and L5–S1, and is more common in females over the age of 65 [40]. Also, anterior slippage up to 30% of the vertebral body was possible, in our study which represented 10.4 (mean value) in SG and 10.7 in CG, respectively. The plain radiographic features in our patients included the essential finding of SD on a lateral view of forward displacement of L4 on L5. We took into consideration that a "listhesis" represents a rotary deformity and not a simple forward displacement [8] and all had DS classified as Meyerding grade I. None of the patients had progression of DS and the degree of slip on the follow-up radiograph was preserved.

We explored the lumbar segment of vertebral column (L1–L4) with a DXA scan, frequently used for defining Op noninvasively [41] in all patients above 50 years, especially females [38]. In 2012, link mentioned that the association between altered vertebral BMD and spinal problems including spondylolisthesis, intervertebral disc degeneration, and osteoarthritis were investigated [42], but results were conflicting. Using DXA, higher spinal BMD was associated with a higher prevalence of SD; probably degenerative changes in the vertebral column developed over time may have led to false BMD results, especially for elderly patients [43]. Low BMD (DXA) might play a role in the development of the SD, as mentioned by Livshits *et al*. [44].

We assume that degenerative changes and shear stress affected mostly the L4 vertebrae and gave rise to an increase in BMD since SD and listhesis were mostly detected at this level. This result is similar to other studies [45].

4.4 Conservative treatment

In the females diagnosed with Op and DS there was reduced bone quality, poor stability of the spine, low back pain and various limitations in physical activity, prompting the need for treatment. The treatment began with conservative care, but if this did not benefit the quality of life, surgical stabilization may be needed. Proper conservative management in osteoporotic patients and rehabilitation measures to estab-

lish vertebral function is essential to prevent complications in low grade DS and osteoporotic spines [46]. We applied a complete rehabilitation program and surgical intervention was not necessary because the patient symptoms were controlled and no neurological impairment was highlighted. We did not study men where various slip ranges correlated with the level of exercise, physical activity, or daily walking [3]. For DS, positive results with nonoperative treatments were seen within lower grade slippages (grades 0, 1, 2), but patients were not diagnosed with osteoporosis, as were our subjects [47].

Our rehabilitation program has included physical therapy, kinetic exercises, and bracing. In the medical literature, we have not found other similar studies for osteoporotic patients with DS. In our opinion, physiotherapy before the kinetic program allowed optimal control of the pain dimension in the biopsychosocial model of our patients. It is well established that patients with persistent pain develop fear avoidance and maladaptive pain behavior, deterioration in physical performance and inactivity [48]. Also, the soft tissue becomes much better prepared for kinetic exercises with physiotherapy, especially in the back, pelvis, and paravertebral regions. Although, in patients with grade I SD, pain relief and restoration of function can be achieved using conservative management techniques without the use of a brace [49], we considered that bracing is important in the rehabilitation program because all patients were osteoporotic females.

We applied kinetic exercises for complex dysfunctions of the vertebral column. Our kinetic program was a judicious choice for the two types of pathologies, more precisely a common denominator for reducing symptoms and restoring vertebral functionality. In accordance with Strength of Recommendation Taxonomy, Garet *et al*. [18] established that the exercise program in DS should focus on lumbar flexion, improving pain, self-reported recovery, and return to work versus exercises focusing on lumbar extension (level C) and strengthening specific abdominal/stabilizing muscles, improving pain and functional limitations in general exercises (level B) [18]. The kinetic exercises were chosen for controlling one of the major local reasons of DS, ineffectual muscular stabilization [50].

Exercise, as a nonpharmacological intervention for improving bone mass, has been studied extensively. The kinetic program in DS osteoporotic patients has been adapted both to the functional individual status and to conclusions of other studies. The specific strength training of stabilizing muscles utilizing functional tasks could be beneficial [18]. Spinal stabilization, that helps the patient in finding the neutral position of the spine, and hamstring stretches completed the previous exercises [51].

We could not perform structural spinal rehabilitation, to improve spinal alignment and postural distortions [52], because the vertebral bones had lost their normality, due to osteoporosis and paravertebral soft tissues had a general laxity. So, we preferred extension exercises for the entire vertebral column and hip extension from the prone position, range of motion and strengthening exercises focusing on lumbar flexion and strengthening specific abdominal muscles (isometric or isotonic), bracing for thoracic-lumbar regions, avoidance of stressful activities and educational measures on dynamic and static posture and lifting techniques. During the extension exercises for vertebral columns, the physiotherapist stretched the shortened muscles to enhance contraction of the antagonistic muscles, thus avoiding postural asymmetry; in this way, promoting the postural correction through specific stretching [53].

4.5 Surgical treatment

In recent years, a new surgical technique has been applied with excellent improvement in osteopenic patients (we studied osteoporotic patients) with low-grade isthmic SD (we analyzed low-grade DS) [54].

Spinal surgery in elderly patients with Op has been gaining support [26], but the surgical methods must be adapted if patients are associated with DS.

Many patients with DS and without significant neurological impairment are optimally treated without spinal surgery. If the patient's clinical and functional status (pain, neurological signs) are persistent, then surgical intervention may be appropriate. The two most considered surgical options are decompression/laminectomy and stabilization/fusion (alone or in combination). In patients with grade I or II DS, surgery may be laminectomy alone, laminectomy/noninstrumented fusion or with an instrumented fusion.

In 2009, Lawhorne the 3rd and colleagues mentioned that over a third of operative cases of DS could be controlled with dynamic stabilization rather than decompression [1].

If DS patients are older and had Op, it is recommended that they have no fusion or a non-instrumented fusion (autograft harvested from the laminectomy that may or may not be combined with a bone graft expander combined with autogenous bone marrow aspirate) [40].

Today, various methods, for improving the materials used (polymethylmethacrylate, autogenous bone chips, various types of bone cement), and the design (screw fixation strength, diameter or length of the pedicle screw, cage) of devices, have been performed in osteoporotic patients with DS. A major dilemma is a fragile bone in DS patients and if the instrumentation with adequate biomechanical properties is not available, surgery could be contraindicated. All these strategies have potential disadvantages, and new techniques are needed to improve the safety and effectiveness of spinal surgery and spinal fusion for these patients [26, 29, 55].

Future research will be able to respond to some medical questions such as, what is the role of physical therapy, bracing, traction, or exercise in the treatment of DS [56] when it is associated with Op and what is the long-term result of this rehabilitation program.

4.6 Limitations of our study

A small number of patients, and only a single gender (females), relatively short duration of monitoring, and inclusion criteria that limited dysfunctional status.

5. Conclusions

Careful assessment in osteoporotic patients with DS was necessary to establish the level of all clinical and functional parameters (range of motion, muscle grading and strengthen, activities of daily living impairment, gait) for vertebral column

and lower limbs.

Non-surgical care and rehabilitation program is one of the optimal choices in osteoporotic patients with minimal DS, especially after 60 years of age.

All rehabilitation measures—physical therapy, bracing, exercise, and educational programs—have active roles in maintaining quality of life in osteoporotic females with grade I SD. Bracing and exercises are essential for the correction of a risk of fall, vertebral slippage and preventing vertebral fractures and other neurological complication.

AUTHOR CONTRIBUTIONS

MRT, AMB—conceptualization, DK—methodology, DOA—validation, CK—formal analysis, MRT, AMB, SDN—investigation, SDN—data curation, MRT—writing original draft preparation, MRT, AMB—writing review and editing, DK, CK—supervision; all authors have read and agreed to the published version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by the Committee of Ethics and Academic and Scientific Deontology, nr 140/20.12.2019. We collected a signed informed consent from all participants in our trial.

ACKNOWLEDGMENT

Not applicable.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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How to cite this article: Magdalena Rodica Traistaru, Diana Kamal, Constantin Kamal, Dragos Ovidiu Alexandru, Simona-Daniela Neamtu, Ana Maria Bumbea. Quality of life in osteoporotic patients with low-grade degenerative spondylolisthesis. Signa Vitae. 2022; 18(6): 66-75. doi:10.22514/sv.2022.022.