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REHABILITATION AND LUMBAR SURGERY: THE FRENCH RECOMMENDATIONS FOR CLINICAL PRACTICE

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Keywords: Low back pain ; Rehabilitation; Discectomy; Fusion ; Prosthesis; Lumbar spine

Abstract

Background : Indications and techniques of rehabilitation differ widely across types of lumbar surgery, including timing (before or after surgery) and prescriptions (surgeons but also medical or paramedical professionals).
Objectives : This project aimed to build consensual recommendations for practice in this context.
Methods : The SOFMER methodology was used to establish recommendations for physical medicine and rehabilitation: a steering committee defined the types of lumbar surgery involved and developed the main questions to be addressed; a scientific committee performed a literature review for grading evidence and proposed the first version of recommendations, which were discussed during a dedicated session at the national Physical and Rehabilitation Medicine congress; then an e-Delphi method with cross-professional experts was used to finalise recommendations and reach a multidisciplinary consensus.

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Results : The main questions developed were the value of rehabilitation before and after surgery, timing and type of rehabilitation, benefit of supervision and instrumental rehabilitation, value of patient education, and complementary interventions concerning rehabilitation for discectomy, fusion, and disc prosthesis (excluding decompression for spinal stenosis). The literature review identified 60 articles, but for several of the questions, no article in the literature addressed the issue. The multidisciplinary scientific committee analysed the literature and addressed the questions to propose the first version of a set of 23 recommendations. The congress session failed to answer all questions or to reach consensus for all items. After a three-step e-Delphi, 20 recommendations were retained, for which consensus among experts was reached. The recommendations are applicable only to patients without a neurological lesion.
Conclusions : These recommendations provide important and consensual knowledge to assist clinicians in decision-making for rehabilitation in lumbar surgery. Despite many of the recommendations relying exclusively on expert opinion rather than published evidence, this approach is an important advance to improve concordance among healthcare professionals.

Introduction

Low back pain (LBP) is a highly prevalent, debilitating and costly condition that is still a leading cause of years lived with disability. LBP is mostly considered non-specific, that is, a possible consequence of degenerative disk processes. Despite extensive research, the best way to treat LBP is still under investigation. Non-pharmacological treatments (e.g., advice, exercises, physiotherapy, cognitive behavioural therapy [CBT]) are often proposed at all stages of the disease and seem to be cost-effective [1], whereas recommendations for pharmacological treatments are generally limited [2].

When the lumbar disk is degenerated, causing back pain or disrupted with disk herniation causing radicular pain without motor loss, the treatment is conservative, unless neurological signs appear or pain persists. However, when conservative treatments fail, surgical options (discectomy for disc herniation and fusion or arthroplasty for disc disease) can be proposed [3−5]. Despite the low rate of required surgery, the prevalence of disc surgery is relatively high (0.1% in the United States [6]) and the frequency of lumbar fusion surgery has increased considerably in recent years (e.g., >150% in the United States in the last 3 decades [7]). Surgery has a high success rate in the short-term but decreases with time after surgery [8]. Patients may then experience physical deconditioning, persisting pain, motor impairment, disability and work absenteeism. To regain physical autonomy, rehabilitation accompanying surgical intervention may improve outcomes [9].

Rehabilitation provided before or after lumbar surgery generally includes patient information/education and various exercises such as stability, mobility, or motor control [10]. However, rehabilitation provision is highly variable across centres and countries, with large inconsistencies in patient restriction, education or type of exercises [11]. Generally, surgeons recommend some restrictions for bending, sitting, and lifting for several weeks after lumbar surgery, but not all [12,13]. Success is often claimed for rehabilitation before or after lumbar surgery, but evidence for the modalities, timing, safety, or efficiency are scarce [14]. Basic advice for rehabilitation and activities of daily living after lumbar surgery is available on hospital/clinic websites, but this advice

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is generally the result of practitioners' opinion or teams' experiences. There is a need for consensual care for all professionals involved in the treatment of spine disorders when surgery is needed.

The aim of this paper is to report structured recommendations for rehabilitation before and after lumbar surgery.

Materials and methods

The SOFMER (French society of physical medicine and rehabilitation) three-step method was used [15] including the elaboration of questions for the first step, the literature review for the second, and finally the elaboration of recommendations. The method was completed by an e-Delphi. At the request of the SOFMER, all experts involved in the development of these recommendations were required to indicate any potential conflicts of interest including practice revenue, grant support, and intellectual property in relation to LBP (see end of the article). The AGREE reporting checklist is available in Appendix 1.

ELABORATION OF QUESTIONS RELATED TO CLINICAL AREA OF THE RECOMMENDATIONS

First, the SOFMER defined the clinical area of the recommendations — rehabilitation associated with lumbar spine surgery — and assigned 2 members (PR, AD) to create a steering committee (SC). The SC comprised 9 members (Appendix 2) representing the different modes of practice (academic, private, public) of physical medicine and rehabilitation (PMR). The SC defined the scope of the theme during 2 conference calls. The agreed research question was the common disco-vertebral pathology, defined by disc degeneration, encompassing disc disease associated with natural aging and repetitive strain injuries. Canal or foraminal narrowings, which may concern older adults and have different presentation and therapeutic outcome, were not retained. Similarly, dynamic stenosis or spondylolisthesis was excluded. The therapeutic framework included herniectomies, discectomies, fusions, prostheses and mixed surgery for lumbar disc degeneration. The scope of the recommendations was limited to the indication and the methods of application of rehabilitation. This field does not cover surgical indications, only the consequences of surgery in the context of good clinical practice and for a non-specific discovertebral pathology. Other approaches associated with lumbar fusion, such as the various level numbers, minimally/open techniques and these specificities, were not evaluated. Only adults, with no restrictions on age, severity of disease or comorbidities, were considered.

The SC proposed questions of practices in France for rehabilitation in lumbar surgery, relating to the type, timing and applicability of any recommendations for physiotherapy/rehabilitation before and/or after lumbar surgery (Table 1). After proposals from all experts, the SC developed a list of questions and sub-questions. To ensure the validity of the recommendations, an agreement for the work was obtained from the various French scientific or professional societies of PMR (SOFMER), rheumatology (SFR), traumatic and orthopaedic surgery (SOFCOT), spine surgery (SFCR), physiotherapy (CNO-MK) and general practice.

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LITERATURE REVIEW

LITERATURE SEARCH

A medical librarian (MP) and two SC members (PR, AD) conducted a systematic search of articles in the PubMed, Cumulative Index to Nursing and Allied Health Literature (Cinahl), EMBASE, PsycINFO and PEDro databases published between January 1995 and September 2016 following the strategy detailed in Appendix 3. The literature review was updated before publication (March 2021). The searches were cross-referenced, and articles were selected after screening abstracts to ensure that both a rehabilitation intervention and a lumbar surgery were presented. Only articles published in French or English were considered. Studies had to be relevant to French practice and able to define the foundations of recommendations for education, physiotherapy, and rehabilitation before and/or after lumbar surgery.

Information was recorded on the population, the type of study (controlled trials, randomised or not, cohort, case−control, systematic review), and the quality rated according to the National Agency of Accreditation and Evaluation in Health (ANAES) grid (A, strong scientific evidence; B, scientific presumption; and C, low level of evidence) [16] (Table 2). A list of eligible publications was proposed for analysis.

LITERATURE ANALYSIS

The literature analysis was entrusted to a Scientific Experts Committee (SEC). The SEC consisted of members nominated by the French medical societies, again reflecting the academic, public and private modes of practice in France (Appendix 4). The members of the SEC had to analyse the literature and answer the questions of the SC.

The librarians provided the list and articles to the SEC, who selected the relevant articles to analyse. The SEC experts were randomly formed into 8 pairs, with each pair independently focusing on one predefined question (see Appendix 4). The final reports of each pair of experts were merged to generate the conclusion report of the literature. The results of the literature review were presented at a 1-day meeting financed by SOFMER, and the findings of expert pairs were discussed. The debates were moderated by a member of the SC (AD). Evidence and first recommendations (if any) for each question and sub-question were collected and a conclusion was written by consensus by the 2 experts of each group.

ELABORATION OF RECOMMENDATIONS

TARGET USERS

The recommendations targeted all professionals involved in rehabilitation before and after lumbar surgery: physiotherapists, rheumatologists, neuro and spine surgeons, PMR physicians, general and occupational practitioners.

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Table 1. Questions for practice designed by the steering committee with supporting evidence and associated recommendations.

Theme Indication	Supporting evidence	Recommendation grade
1a. What is the benefit of rehabilitation before lumbar surgery in terms of length of hospital stay and postoperative functional results?		
Benefits of prescribing outpatient physiotherapy. Benefits of rehabilitation in a specialised centre before surgery. Orientation criteria.		
Rehabilitation/physiotherapy [21,22,27]	Level 1[a] and 2* RCTs	C for fusion [a], EA for prosthesis[b], none for discectomy*
Cognitive behavioural support [24,26,79]	1 survey[a], 1 cohort[a]	None
Physical activity	Unspecific	EA for all
Orientation criteria [25,26]	2 small cohorts*	None
1b. What is the benefit of rehabilitation after lumbar surgery in terms of length of hospitalisation and postoperative functional results?		
Benefits of prescribing outpatient physiotherapy. Benefits of rehabilitation in a specialised centre after surgery. Orientation criteria.		
Rehabilitation/physiotherapy [3,8,28,30,32,33,35–37,39,41–49]	MA*,[a], level 1*,[a] and 2*,[a] RCTs; level 3* and 4[b] studies	B for discectomy*, C for fusion [a], EA for prosthesis[b]
Cognitive behavioural support [29–31,34,48]	MA[a], Level1*,[a]and 2[a]RCTs	B for fusion [a], C for discectomy*, EA prosthesis[b]
Orientation criteria [28,35,50,71]	Level 1*,[a], Level 2[a], Cohort[b]	C for discectomy*, EA for fusion [a] and prosthesis[b]
Timing		
2. What are the benefits of very early rehabilitation after surgery (immediate post-op), of deferred rehabilitation (after 4 to 8 weeks) [8,9,20,28,29,33,36–38,40,42,52,55–59]	MAs*,[a], level 1–3*,[a] RCTs, Cohort[b]	B for discectomy* and fusion [a], EA for prosthesis[b]
Support method		
3a. What types of physiotherapy exercises and treatments have shown their effectiveness? for what risks (if they exist)? what observance?		
High intensity [8,40,41,45,55]	MA*, Level 1–3* RCTs	A for discectomy*
Extensors strengthening [41,43,44]	MA*, level 1 RCT	B for discectomy*
Other	No data	EA
Instrumental [32,44,62,63,66]	Level 2*,[a] and 3* RCTs	None
Group vs individual	No data	None
Supervised vs unsupervised rehabilitation [8,9,11,45,67]	MAs* and level 1 and 2*,[a]	B for discectomy*, EA for others
3b. What is the impact of an educational program?		
Value of information given to the patient/of a structured educational program [21,23,24,29,30,34,47,49,64]	Level 1*,[a] and 2*,[a] RCTs, Mixed surgery surveys and level 3 study	B for discectomy* and fusion [a], EA for prosthesis[b]
Value of a self-management program	No data	EA for all
How the patient is integrated into the care process	No data	None
3c. Benefit of complementary solutions? For what benefits/risks?		
Benefits of a postoperative lumbar orthosis	No data	EA for all
Value of physical means (electrophysiotherapy, hot, cold, etc.)	No data	None
Massage	No data	None

EA, expert agreement; MA, meta-analysis; RCT, randomised control trial.
* discectomy,.
[a] fusion,.
[b] prosthesis.

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Table 2. The Agency for Accreditation and Evaluation in Healthcare (ANAES) scoring grid for level of evidence [16].

Grading of published trial results
1. Randomized controlled trials of high power
Meta-analysis of randomised controlled trials
Decision based on well-designed trials
2. Randomized controlled trials of low power
Comparative well-designed non-randomised trials
Cohort studies
3. Case–control studies
4. Comparative studies with major bias
Retrospective studies
Case series
Grading of recommendations
A. Established scientific evidence (level 1 of evidence)
B. Scientific presumption (level 2 of evidence)
C. Low level of evidence (levels 3 and 4 of evidence)

EXPERT CONCLUSIONS

A dedicated session at the SOFMER congress (October 2016) was scheduled for the presentation of each expert group conclusions and to vote for the first version of the recommendations. The aim of this phase was to obtain feedback from health professionals for their everyday practice (physicians, surgeons, physiotherapists) and to discuss a first version of the recommendations. The experts of this session were members of the SEC, designated by their professional society, and others regularly attending the congress. The SOFMER method was also applied for this session: presentation of the review by subgroups (see questions of the SC in Table 1), collective discussion of the results and answers to questions elaborated by the SC and SEC before the session owing to lack of clarity, inconsistencies, or absence of information. All comments and answers to the questions were collected by a member of the SEC and added to the congress report. According to the preceding steps, the SEC proposed the draft of recommendations to the SC.

E-DELPHI

Next, a Delphi method was used to complete and validate the recommendations. The Delphi method is a validated method to obtain consensus in a defined clinical area [17], particularly when practices are poorly supported by evidence and when opinions of healthcare professionals are important [18]. Because questions were answered by Web support, the method is called an e-Delphi.

The aim of the e-Delphi was to 1) determine the pertinence of each recommendation and improve comprehension and syntax and 2) provide comments and additional information to include in recommendations or add a new one. The first step was to determine the questions with only a partial or no answer after analysis of the literature and results of experts failed to provide an answer or revealed new questions. Only major questions achieving consensus were addressed. Questions related to the routes of entry, the number of levels operated, paediatric or geriatric populations or specific situations were not addressed as a priority.

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The panel consisted of the key players involved in treatment: physiotherapists, occupational therapists, neurosurgeons, orthopaedic surgeons, PMR physicians, rheumatologists, and general practitioners, with ideally half of the panel to consist of freelance/community physicians (Appendix 5). Expert groups were asked to each provide 2 candidates and associations to provide 5 experts; SOFMER was also asked to provide experts in each field. All responses were anonymous.

E-Delphi members were asked to rate the relevance of each recommendation between 0 (irrelevant) and 6 (maximum relevance), according to the following questions: 1) Is the recommendation clearly defined and comprehensible?; 2) Can the recommendation be applied in your own practice?; 3) Are the interventions and treatment settings described well enough for you to replicate with your patients?; 4) Do the likely treatment benefits outweigh the potential harms?; and 5) Is another recommendation needed? They also gave their opinion on the form and content of the draft recommendations and responded to questions for the recommendations falling within their disciplinary sub-groups (PMR physicians or surgeons). Finally, they could suggest a maximum of one new recommendation. This first round resulted in eliminating the lowest-priority items unless modifiable (low rate of pertinence), clarified the first recommendations, and provided the opportunity to add new recommendations.

In the second round, participants rated the recommendations selected during the first round according to priority. Further comments were encouraged. A cut-off of 70% agreement was set for each recommendation raised by respondents during rounds 1 and 2 of the e-Delphi. In the third round, the recommendations were scored and only those rated by 80% of the panel as >3/6 for priority and/or application were kept.

After validation by the SC, the recommendations were translated into English via a standardised translation/back-translation procedure.

Results

The study flowchart is in Fig. 1.

ELABORATION OF THE QUESTIONS

The SC met in October 2016 to discuss and choose the eligible questions. First, 4 types of lumbar surgery were proposed for recommendations: discectomy, fusion, prosthesis, and decompression for spinal stenosis. However, decompression was excluded because the population targeted, the objectives of rehabilitation, and the expected impact of such guidelines were considered different by more than half of the SC.

Three major question were retained, divided into 2 or 3 sub-questions, for a total of 20 sub-questions. The first questioned the benefits of rehabilitation (1a) before surgery or (1b) after surgery in terms of length of hospitalisation and postoperative functional outcomes; the second (2) the optimal timing for rehabilitative care; and the third the type of rehabilitation including the risk and the observance and

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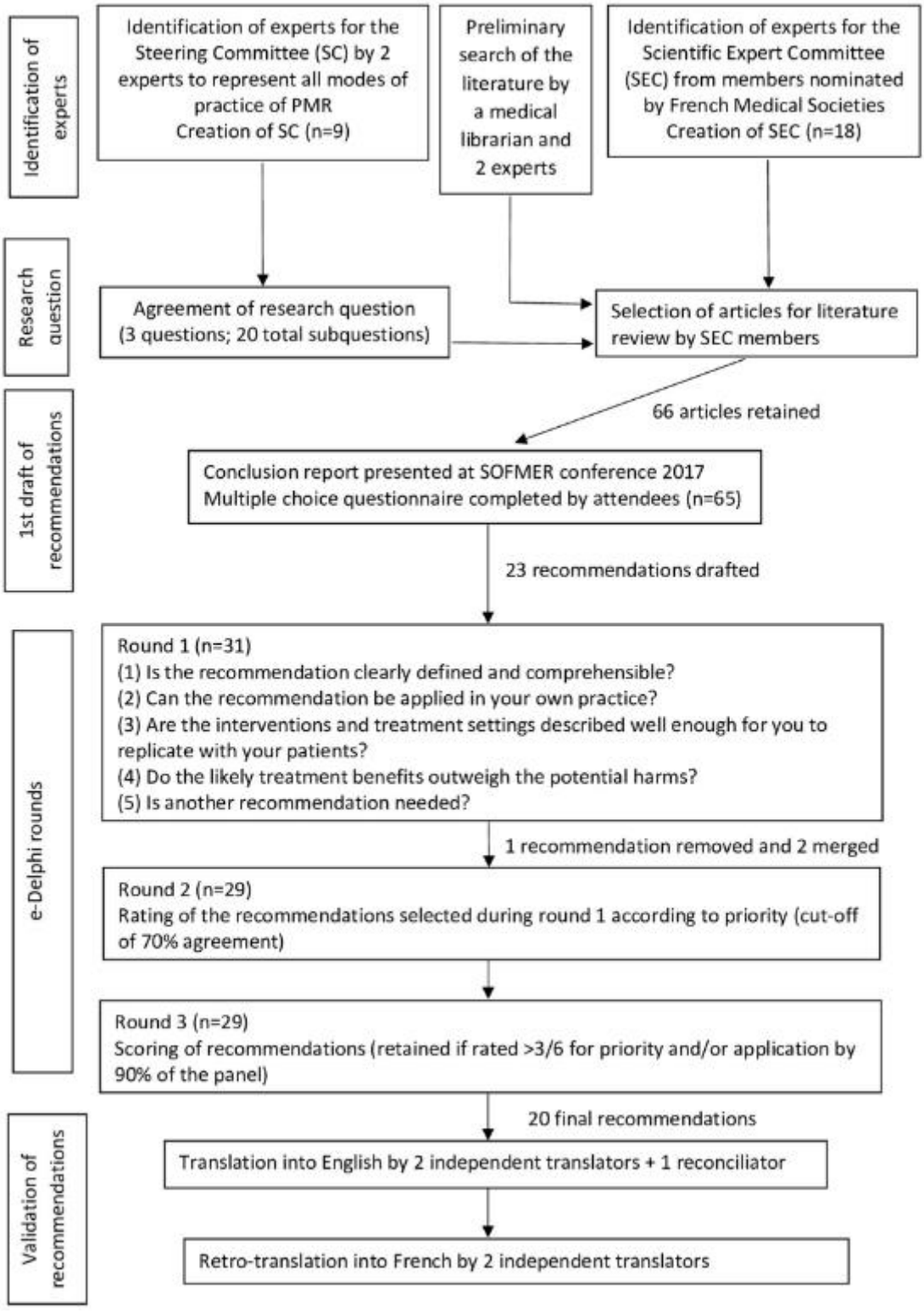
identification of (3a) exercise types, instrumental rehabilitation, groups or individual, supervision (3b) educational program and (3c) use of orthoses (see Table 1 for details).

Figure 1. The general flowchart of the recommendations development.



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Eighteen SEC experts performed the literature review: 4 experts for the first question and 2 sub-questions, 2 for the second question, 10 for the third question, with 2 for each of 5 sub-questions.

LITERATURE REVIEW

A systematic review was conducted according to PRISMA criteria [19]. A total of 766 documents were retrieved by the literature search (Fig. 2). Of these, 298 were duplicates and were removed. A further 141 were removed after screening abstracts and 42 after evaluating the entire article. Finally, 66 documents were retained: 46 randomised controlled trials (RCTs), 7 observational studies, 10 systematic reviews/meta-analyses and 3 surveys. No other documents were included (conference abstracts, recommendations of societies, etc.). The overall quality of the studies was low (Table 3). Studies of disc surgery reached level 1–2 evidence, but only a few studies of low-level evidence were available on lumbar fusion and prosthesis. Rehabilitation interventions were heterogeneous (e.g., type of strengthening [muscles, duration, frequency] or type of education [support, formalisation, timing]), so results were underpowered.

For a number of questions, no relevant articles were found from the literature search, or the articles failed to conclude on the risk/ benefit of interventions.

Figure 2. The PRISMA flowchart of the literature search.

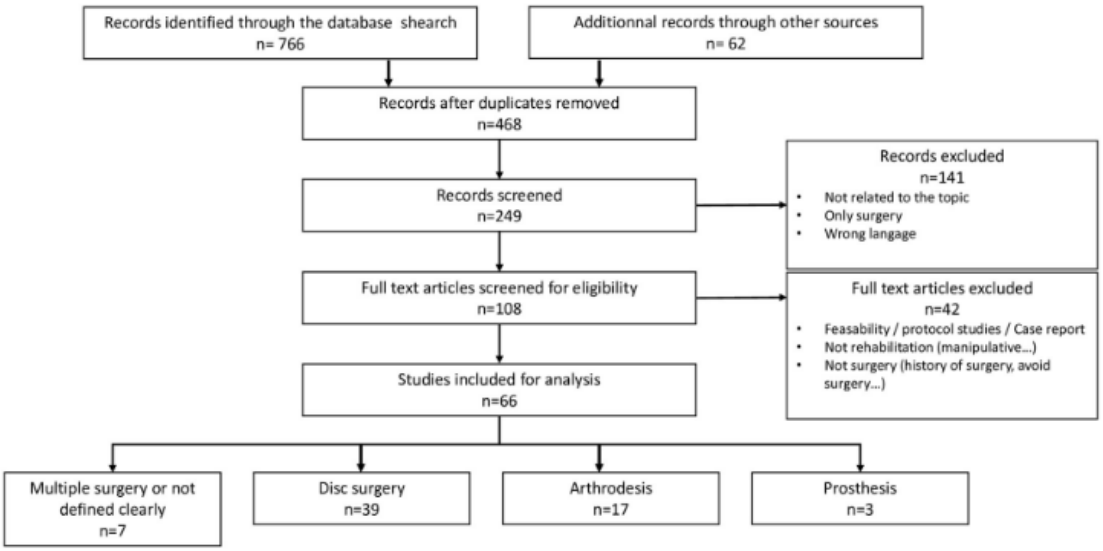

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Table 3. Results of the literature review.

Authors	Year	No. of participants	Type of study	Country	Type of surgery	Objectives clearly defined	Study is comparative	Study is prospective	Study is randomized	Number of subjects defined a priori	Population described and matched with these usually treated	Criteria relevant, robust and all used	Statistics relevant	Intention to treat analysis	Results coherent with aims	Clinically relevant and defined	Treatment modalities transposable in real life	Level of Evidence
Abbott et al. [29]	2010	107	RCT	Sweden	Fusion	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1
Beneck et al. [49]	2014	98	RCT	USA	Discectomy	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	1
Choi et al. [44]	2005	75	RCT	Korea	Discectomy	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	3
Christensen et al. [30]	2003	90	RCT	Denmark	Fusion	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y	2
Danielsen et al. [41]	2000	63	RCT	Norway	Discectomy	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1
Demir et al. [45]	2014	44	RCT	Turkey	Discectomy	Y	Y	Y	Y	N	Y	Y	Y	P	Y	Y	Y	2
Dolan et al. [46]	2000	21	RCT	UK	Discectomy	Y	Y	Y	Y	N	Y	N	N	P	Y	N	Y	3
Donaldson et al. [61]	2006	93	RCT	New Zealand	Discectomy	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1
Erdogmus et al. [37]	2007	120	RCT	Austria	Discectomy	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1
Filiz et al. [67]	2005	60	RCT	Turkey	Discectomy	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	2
Hebert et al. [25]	2013	61	RCT	USA	Discectomy	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1
Johansson et al. [71]	2009	59	RCT	Sweden	Discectomy	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1
Ju et al. [66]	2012	14	RCT	Korea	Discectomy	Y	Y	Y	Y	N	Y	N	Y	P	Y	Y	Y	3
Kang et al. [32]	2012	60	RCT	Korea	Fusion	Y	Y	Y	Y	N	Y	N	P	N	N	N	Y	2
Kim et al. [63]	2010	30	CT	USA	Discectomy	Y	Y	Y	N	N	N	N	Y	P	Y	Y	N	2
Kim et al. [62]	2010	40	CT	USA	Discectomy	Y	Y	Y	N	N	N	N	Y	N	Y	Y	N	3
Kjellby-Wendt et al. [42]	1998	54	RCT	Sweden	Discectomy	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	2
Kjellby-Wendt et al. [57]	2001	50	RCT	Sweden	Discectomy	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	2
Kjellby-Wendt et al. [58]	2002	49	RCT	Sweden	Discectomy	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	2
Kulig et al. [47]	2009	98	RCT	USA	Discectomy	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1
Louw et al. [21]	2014	65	RCT	USA	Discectomy	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	P	Y	2
McGregor et al. [50]	2010	338	RCT	UK	Multiple	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1
McGregor et al. [64]	2012	177	CT	UK	Multiple	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	N	3
Millisdotter et al. [38]	2007	56	CT	Sweden	Discectomy	Y	Y	Y	N	N	Y	N	N	N	Y	Y	Y	3
Newsome RJ [3]	2009	30	RCT	UK	Discectomy	Y	Y	Y	Y	N	Y	Y	N	N	Y	Y	Y	2
Nielsen et al. [22]	2010	73	RCT	Denmark	Fusion	N	Y	Y	Y	Y	Y	Y	N	Y	N	N	Y	2
Nielsen et al. [27]	2008	73	RCT-CE	Denmark	Fusion	N	Y	Y	Y	Y	Y	Y	N	Y	N	N	Y	2
Oestergaard et al. [33]	2012	82	RCT	Denmark	Fusion	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1
Oestergaard et al. [54]	2013	82	RCT	Denmark	Fusion	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1
Oestergaard et al. [36]	2013	82	CE	Denmark	Fusion	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1
Ogutluler Ozkara et al. [39]	2015	30	RCT	Turkey	Discectomy	Y	Y	Y	Y	N	Y	Y	Y	P	Y	Y	Y	2
Ostelo et al. [48]	2003	105	RCT	Netherlands	Discectomy	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1
Ostelo et al. [72]	2004	105	RCT- CE	Netherlands	Discectomy	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	1
Rolving et al. [23]	2016	90	RCT-CE	Denmark	Fusion	y	y	Y	Y	Y	P	Y	N	N	N	Y	Y	2
Rolving et al. [24]	2015	90	T	Denmark	Fusion	Y	Y	Y	Y	Y	P	Y	N	N	N	Y	Y	2
Søgaard et al. [35]	2008	90	CE	Denmark	Fusion	Y	Y	Y	y	N	Y	N	Y	Y	Y	Y	Y	2
Søgaard et al. [34]	2006	90	CE	Denmark	Fusion	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y	2
Scrimshaw et Maher [60]	2001	81	RCT	Australia	Multiple	Y	Y	Y	Y	Y	Y	Y	Y	P	Y	Y	Y	1
Yilmaz et al. [40]	2003	42	RCT	Turkey	Discectomy	Y Objectives clearly defined	Y Cohort constitution defined	Y Same stage of the disease	Y (non)inculsion criteria defined	N Bias and confution factors described	Y Outcome respected and complete	Y Criteria relevant, robust and all used	P Interpretation objective	N Results ajusted for others factors	Y Level of Evidence	Y	N	3
Canbulat et al. [52]	2011	20	Cohort	Turkey	Prosthesis	Y	Y	Y	Y	Y	Y	Y	Y	P	3			
Carragee et al. [13]	1996	50	Cohort	USA	Discectomy	Y	N	Y	Y	N	Y	Y	Y	N	3			
Carragee et al. [79]	1999	152	Cohort	USA	Discectomy	Y	N	Y	Y	N	Y	Y	Y	N	3			
Green et al. [28]	2015	600	Cohort	Australia	Prosthesis	Y	N	N	Y	N	N	N	Y	N	4			
Johansson et al. [26]	2010	59	Cohort	Sweden	Discectomy	Y Objectives clearly defined	Y Population described	N (non)inculsion criteria defined	N Data collection quality and modalities described	Y Statistics relevant	Y Bias and confu-tion factors described	Y Results verifi-ble with raw data	Y Level of Evidence	Y	3			

(*continued on next page*)

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Table 3. (Continued)

Authors	Year	No. of participants	Type of study	Country	Type of surgery	Objectives clearly defined	Study is comparative	Study is prospective	Study is randomized	Number of subjects defined a priori	Population described and matched with these usually treated	Criteria relevant, robust and all used	Statistics relevant	Intention to treat analysis	Results coherent with aims	Clinically relevant and defined	Treatment modalities transposable in real life	Level of Evidence
Louw et al. [70]	2012	89	Survey	Multiple	Multiple	Y	Y	Y	Y	Y	N	N	4					
Rushton et al. [20]	2014	71	Survey	Denmark	Fusion	Y	Y	N	Y	Y	N	Y	4					
Williamson et al. [59]	2007	77	Survey	UK	Discectomy	Y	N	Y	Y	N	N	N	4					
						Objectives clearly defined	Data sources described	Selection criteria relevant	(non)inculsion criteria defined	Non published studies are considered	Analysis modalities described	Synthesis method described	Results described	Studies level discussed	Conclusions are supported by valid data	Synthesis answers the question	Level of Evidence	
Gilmore et al. [10]	2015	231	SR		Multiple	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	1	
Greenwood et al. [31]	2016	237	MA		Fusion	Y	Y	Y	Y	N	Y	Y	Y	Y	P	Y	1	
Oosterhuis et al. [8]	2014	154 to 272	MA		Discectomy	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	1	
Ostelo et al. [12]	2002	?	SR		Discectomy	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	1	
Ostelo et al. [9]	2009	95 to 122	SR		Discectomy	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	1	
Rushton et al. [43]	2011	635	MA		Discectomy	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	1	
Rushton et al. [55]	2012	159	MA		Fusion	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	1	
Snowdon et al. [56]	2016	101	MA		Discectomy	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	1	

Studies are grouped according to study type. Quality is graded according to the ANAES grid (Table 2). CE, cost-effectiveness; CT, controlled trial; MA, meta-analysis; P, partial or not defined; RCT, randomized controlled trial; SR, systematic review; T, trial.

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QUESTION 1A: WHAT IS THE BENEFIT OF REHABILITATION BEFORE LUMBAR SURGERY IN TERMS OF LENGTH OF HOSPITALISATION AND POSTOPERATIVE FUNCTIONAL RESULTS?

One survey showed that pre-surgery physiotherapy is used by some UK practitioners [20]. One RCT (Level 2 evidence) found that physiotherapy before lumbosacral radiculopathy surgery improved satisfaction and recourse to care at 1 year but had no impact on pain or function [21]. However one RCT (Level 1) showed an advantage of prehabilitation and early rehabilitation on function, time to recovery and satisfaction in fusion surgery [22]. One study (Level 2) evoked the effectiveness of a CBT-type program before and after surgery (Oswestry Disability Index [ODI] at 3 months, Fear-Avoidance Beliefs Questionnaire at 6 months, quality of life [QoL] at 1 year) but not on ODI at 1 year [23,24]. Two small cohort studies provided indirect evidence for the prognostic value of preoperative impairments accessible to rehabilitation [25,26]. The Johansson et al. study (Level 3) showed a link between fears and erroneous beliefs and the low hope of returning to work and unfavourable outcome of a discectomy, thus suggesting the potential value of preoperative therapy to modify fears, beliefs and expectations [26]. However, Hebert et al. (Level 2) did not show any link between preoperative deficiencies and surgical outcome [25]. Thus, pre-operative education may help assuage fears and beliefs, improving satisfaction and avoiding recourse to care at 1 year, but not pain or function (Level 3). Two studies [23,27] considered cost-effectiveness of rehabilitation before surgery, confirming its usefulness, with one demonstrating cost-effectiveness [27] and the other being neutral [23].

QUESTION 1B: WHAT IS THE BENEFIT OF REHABILITATION AFTER LUMBAR SURGERY IN TERMS OF LENGTH OF HOSPITALISATION AND POSTOPERATIVE FUNCTIONAL RESULTS?

A. *prostheses*. The literature search revealed no robust data on the benefit of rehabilitation after prosthetic surgery or reasons for opting or not for postoperative rehabilitation (referral criteria). One retrospective study of 40 patients showed increased effectiveness with intensity of the rehabilitation on pain, function and QoL at 3 and 12 months with a self-exercise program compared to supervised sessions 1–3 or 4 sessions/week, starting 3 months after surgery [28] (Level 4).

B. *fusion*. There was no distinction according to the surgical approach and the use or not of mini-invasive technique for spinal fusion in the literature. There were strong arguments for proposing post-fusion rehabilitation for pain and function [29–33]. Intensive rehabilitation (extensors strengthening) seems more effective than less intense rehabilitation at 3 months on function but not at 6 months, with no effect on pain at 3 and 6 months, QoL at 3 months, return to work or cost [31,32]. There was low-quality evidence for the use of exercise therapy (with extensors strengthening) (Level 3) with cognitive behavioural support (e.g. back cafe, behavioural education, coping, motivation) (Level 2) [30,34].

However, behavioural support combined with exercise therapy (vs exercise therapy or usual care) improved pain (3, 6, 12 months), function (3 and 6 months), fears and beliefs (3 and 6 months) and return to work but had no impact on QoL [29–31,34]. Rehabilitation could be implemented gradually over the first 3 months without significant adverse effects [29].

The cost-effectiveness of some of the studies was analysed [30,33]. Although not different, the probability of better incremental cost-effectiveness ratio was superior for standard outpatient regimen

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with behavioural supplement compared to individual hospital physical training supervised by a physiotherapist [35]. For timing, starting earlier (6 vs 12 weeks) was more costly and less effective [36].

C. *discectomy*. Many RCTs and meta-analyses covered this subject. Very early active rehabilitation after discectomy may shorten independent mobility and return to work [3]. There was strong evidence (Level 1) that dynamic exercise therapy (e.g., mobility, strengthening, stabilisation, aerobic, stretching) improves pain and function at 3, 6 and 12 months [3,37–40]. High-intensity exercises were superior to lower intensity ones [8,41–43] or control [44–47], whereas the usefulness of graded behavioural activity was not confirmed [48] (Level 1). Regardless of the modalities, low-intensity exercises were not efficient on pain and function [8,37] (Level 1). There was low evidence for improved QoL and fear avoidance [48,49] (Level 3), although a return to work was not shortened by dynamic rehabilitation at 3 and 6 months [41] (Level 2). One study found no benefit of providing rehabilitation or education after surgery, although nerve root compression was not limited to disc herniation alone (Level 1) [50]. A cost-effectiveness analysis of this study did not demonstrate any difference between a booklet versus no booklet or rehabilitation versus no rehabilitation [51]. Limiting post-operative restrictions did not seem to increase complications at 2 years [13].

QUESTION 2: OPTIMAL TIME FOR REHABILITATIVE CARE

A. *prostheses*. Again, there were few studies on the topic. An observational study (Level 3) [52] reported good results (but no control group) for management, consisting of staying active (walking, stairs, etc.) until the third week, progressing to lumbopelvic mobilisation exercises (pelvic tilt) from the 4th to 6th week, before considering dynamic rehabilitation (7 weeks to 6 months) and return to sport (>6 months). In a retrospective study (Level 4), physiotherapy started at the 4th week [28].

B. *fusion*. There were far fewer studies on spinal fusion, with a great inter-study variability. One study (Level 1) compared physiotherapy initiation at 6 versus 12 weeks and reported better results in the latter group [33]. Indeed, poorer long-term results were found with early initiation for disability and pain [33], but results were comparable for walking distance and fitness (Level 1) [54]. An economic evaluation showed increased support costs when physiotherapy was started before 3 months [33]. However, another study (Level 1) described treatment from 3 weeks with implementation during the first 3 months [29]. Although a survey indicated that 59% of respondents offered physiotherapy sessions only if necessary, physiotherapy was most often offered at 2 to 6 weeks [20]. Therefore, a compromise of 6 weeks could be suggested (minimally invasive surgery to limit pain) and after 12 weeks for more extensive lumbar surgery [33]. A meta-analysis of post-fusion physiotherapy included only two RCTs [55] and was inconclusive for timing. Altogether, it appears best to propose rehabilitation in the third month for pain and function.

C. *discectomy.* The literature showed great heterogeneity of timing, with poor distinction between in/outpatient surgery and vague or missing information on type of rehabilitation. Globally, evidence (Level 1) supported that post-operative physiotherapy was beneficial [8,9,42,[56], [57], [58]]. However, one study (Level 1) found similar results between lumbar exercises and massages of the cervical region (sham group) [37]. The most common initiation timing was between day 4 and week 6, although some studies started earlier and continued longer (e.g., Erdogmus et al.), which ran from week 1–12 [37]. A UK survey found good results for the initiation of therapy between 4 and 6 weeks [59], which was

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confirmed by a systematic review [9]. Owing to limited comorbidities, it seems worthwhile to start earlier for younger patients (Level 3) [38]. No study started later than 12 weeks, which questions the usefulness of late rehabilitation in practice. A few studies compared 2 treatment times: one RCT of 30 patients found improved outcomes in patients starting treatment within 2 h after surgery versus day 1 post-surgery (Level 2) [3]. Another RCT compared stabilisation exercises starting after 2 weeks versus 6 weeks, finding early treatment slightly more effective but on a small sample and a young population (mean 37 years old) [38]. Good results of early rehabilitation after discectomy persisted at 1 year [57] and over 5 years [58] (Level 2). Furthermore, 2 meta-analyses looking at decompression by laminectomy and discectomy found no increase in side effects (re-operation, re-herniation) with rehabilitation before 4 weeks but improved pain [8,56].

QUESTION 3A: WHAT TYPES OF PHYSIOTHERAPY EXERCISES AND TREATMENTS HAVE SHOWN EFFECTIVENESS? FOR WHAT RISKS (IF THEY EXIST)? WHAT ADHERENCE?

Subpart I: exercises. There is an overall agreement on the value of high-intensity rehabilitation regardless of surgery on short-term pain and function [8,40,41,45,57] (Level 1–2). The dynamic strengthening of back extensors was efficient after discectomy for pain and function at 3 months but not at 1 year, with a probable dose effect [41,43,44] (Level 1–3). However, there was moderate-quality evidence to justify any choice of back strengthening method (isokinetic or aquatic type, duration, other muscles) [41,43,44] (Level 1–3). None of the rehabilitation modalities applied to back surgery (e.g., lumbopelvic mobility, stretching, stabilisation, strengthening, proprioception, sheathing, McKenzie) imposed a specific risk [8,56] (Level 1). However, most studies combined multiple therapeutic exercises, preventing the detection of specific effect. In contrast, some were tested individually, such as neuro-dynamic mobilisations [60] or prolonged gym-based exercises [61], with no effect detected (Level 1); isolated extension exercises (McKenzie type) with probable effect in the short-term (Level 3); and aerobic exercises on a treadmill proving effective in the short-term (Level 3).

Finally, for all surgeries, compliance was low to moderate for institutional rehabilitation programs [38,60,62-65] (Level 1–3), with very low-level evidence suggesting that compliance at home was good (Level 3).

Subpart II: instrumental versus non-instrumental rehabilitation. Only 6 studies assessed instrumental rehabilitation after back surgery. Five studied the MedX-type machine (both after discectomy and fusion) to strengthen extensors [32,44,62,63,66] and one studied instrumental rehabilitation but without specifying the material used [65]. Instrumental rehabilitation allows for specific work on the trunk extensors, resulting in increased strength [62,63,66], lower pain [62,66], and functional improvement [32,62] (Level 2–3). None of the studies reported side effects, which indicates good tolerance of the machine (Level 2–3). Only inconclusive results supported the utility of poorly specified instrumental modality (isometric or isokinetic use) over non-instrumental rehabilitation [32,44,62,63].

Subpart III: supervised versus unsupervised rehabilitation care. Twenty-three articles considered supervised versus unsupervised rehabilitation, mainly for discectomy-type surgeries. However, the concept of "supervised" was vague, encompassing the notion of transition to independent activities without a typical rehabilitation session, spacing of the sessions (2 sessions/week), and modification of the content (lumbar hygiene). Supervised physiotherapy was defined as exercise programs under the

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supervision of a physiotherapist (i.e., conventional physiotherapy sessions). Duration and frequency of sessions differed among studies, ranging from 30 to 90 min, 2–4 sessions/week, for up to 8 weeks. Various articles also reported accompaniment/support via discussion groups led by physiotherapists or others, more similar to supervised than unsupervised sessions.

Two studies (Level 2) concluded a benefit in supervising rehabilitation after discectomy [45,67]. Others (Level 1–3) provided limited information on supervised physiotherapy [37,40,41,46,66]. One study [50] did not report any difference of supervised rehabilitation compared to usual care, with or without an educational booklet (Level 1). However, meta-analyses [8,9,12] including 22, 3 and 13 studies found only a low level of evidence, preventing conclusion on whether supervised exercises were superior to unsupervised exercises on pain or function in the short-term.

QUESTION 3B: WHAT IS THE IMPACT OF AN EDUCATIONAL PROGRAM?

A national audit of 89 surgeons reported that 79% had a routine protocol, 35% gave written instructions and 55% did not refer their patients to physiotherapists [11]. The standard educational content [11,68,69] describing normal anatomy, anatomical data from herniated disc and surgery, and lumbar hygiene rules covered the most frequent patient questions. American spine surgeons considered education before or after lumbar surgery to be common practice, especially before surgery, and beneficial [70].

This pre-operative education led to better experience with surgery and less recourse to care (Level 2) [21], and CBT education led to earlier return to work and increased QoL [23,24] (Level 2). Patients expressed interest in meeting other patients who had surgery (Level 2) [64].

The literature highlighted the value of including biopsychosocial elements in care (Level 2) [34]. Post-operative education in the form of booklets, discussion group "back café" [30,34], patient therapeutic education [29,47,49] (Level 2) was beneficial on function, activities of daily living and QoL [30,47,49], pain [29,30,49], recourse to primary care [30,34], absenteeism and earlier return to work [30]. The addition of cognitive and educational management appeared to be cost-effective for intervention after fusion in one (Level 2) study [34].

QUESTION 3C: BENEFITS OF COMPLEMENTARY SOLUTIONS (ORTHOSIS, COLD/HEAT, NEUROSTIMULATION, ETC.)? FOR WHAT BENEFITS/HARMS?

No article determined whether complementary solutions had a benefit or a risk in the context of lumbar surgery.

An updated search up to June 2020 identified only 9 articles, which are included in only the discussion because they were not analysed by the SEC and were used as confirmatory data of the recommendations.

PRESENTATION OF EXPERT'S CONCLUSIONS

The conclusions of the experts' analysis of the literature were presented during the national PMR congress. The session was chaired by members of the SC (AD, PR). Fifty multiple-choice questions elaborated by the SC (Table 1) were presented to the 65 multidisciplinary professionals present at the

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session. The professionals comprised members of the SEC and PMR physicians, surgeons and physiotherapists at the congress. The list of questions with responses are detailed in Table 1. Most results failed to reach a consensual response or agreement between professionals. The major limitation was the heterogeneity of practices and points of views. For example, to the question "Would you propose rehabilitation before lumbar surgery?" the responses were split equally. This question validated only the usefulness of rehabilitation before fusion or prosthesis but not discectomy because leg pain may limit physiotherapy interventions. Overall, many questions revealed quite different practices underpinned by various experiences (notably for prosthesis). Therefore, the e-Delphi method was applied to finalise the recommendations.

E-DELPHI

From the information gathered from the systematic review and refined by the congress session, 23 recommendations were drafted by the SEC and submitted to the e-Delphi panel. Thirty-one experts participated in the first round (10 physiotherapists, 7 spine surgeons, 7 rheumatologists, 7 PMR physicians, 1 pain specialist, 1 occupational practitioner). Only one recommendation fell below the 80% agreement cut-off (R22: Wearing a corset or a belt should be considered on a case-by-case basis, taking into account the patient's pain level and exposure to stresses, and should be as short as possible [Expert agreement]). However, the experts recommended keeping and clarifying this recommendation for the second round. Although reaching 80% agreement, one was removed because it was not clarified after 2 more questions on maximum capacities by the expert (R23: After lumbar surgery, intensive rehabilitation corresponds to a level of activity close to the patient's maximum capacities [Expert agreement]). Two recommendations were merged by keeping the choice of validated resources (Back book, Health Insurance booklet) instead of general contents about pathophysiology, ergonomics and anatomy. One recommendation was accepted without modification (R12: Strengthening the para-vertebral muscles [especially the extensors] is recommended after lumbar surgery [Grade C]), and 2 had minor changes (R21 & R22). All others were clarified with major revision suggested by the panel. Fig. 1 illustrates the results of the e-Delphi.

Twenty-nine experts participated in round 2 (9 physiotherapists, 6 spine surgeons, 7 rheumatologists, 7 PMR physicians). Seven recommendations needed major revision to achieve consensus. Fourteen achieved consensus with only minor revision (>80% agreement).

The same 29 experts participated in round 3. Two recommendations were discussed for possible fusion and extension to include prosthesis (R5: After lumbar stabilisation, the recommendation is to resume and maintain daily activities from the first week or as soon as possible after surgery [Expert agreement] and R8: After lumbar discectomy, the resumption of activities of daily living [including walking] can begin within the first 15 postoperative days [Grade B]). The text was homogenised and extended to prosthesis, becoming a new recommendation: "After lumbar surgery, it is recommended that patients resume activities of daily living within the first 2 weeks postoperatively (Grade B for discectomy; Expert agreement for fusion and prosthesis), walking immediately and gradually introducing spine movements (Expert agreement)" and was agreed upon by 93% of the panel. A supplementary question about the activities that should be limited in fusion was added and 2 restrictions proposed by at least 80% of the panel were retained.

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After the final round, 20 recommendations remained: 2 before surgery, 4 general recommendations for after surgery, 3 for after discectomy, 3 for after fusion, 2 for after prosthesis and 6 for specific outcomes after surgery. The panel agreed on a statement to add: "These recommendations apply to only patients without neurological lesion. The recommendations should be adapted to individual situations, types of surgeries and the patient's plan."

Finally, the French recommendations were translated into English by 2 native English speakers, with a third native speaker performing the reconciliation. Then 2 French native speakers back-translated the recommendations and the final version was verified with the original.

Discussion

Here we report the first recommendations for rehabilitation in low back surgery. This is the result of a multidisciplinary work from the key disciplines dealing with LBP using a formal methodology (SOFMER) [15]. Indeed, rehabilitation before or after lumbar surgery, whether for discectomy, fusion or prosthesis, is not supported by evidence and is frequently the result of individual initiatives. For example, post-operative recommendations in the United Kingdom differ across surgeons, with 35% providing written instructions, 45% referring to a physiotherapist and 18% advocating a corset after surgery [11]. This may have several consequences on the treatment course, on outcomes because timing and type of care are not supported by evidence [34,50] and on the economic burden because individual decision-making may lead to inefficient treatments, poor outcomes and inappropriate health costs [35,51]. Moreover, the use of consensus guidelines improves the quality of healthcare when recommendations are supported by evidence-based practice care.

The 3 types of lumbar surgery considered reflect the high volume of patients usually treated for LBP and/or radiculopathy. Considering the high prevalence of LBP and the rate of surgery, this observation may be generalisable to other countries. However, this work did not cover rehabilitation surrounding lumbar decompression for spinal stenosis, which was considered to involve older populations with different challenges [73].

Except for disc surgery, the literature review did not provide robust enough evidence for decision-making (see level of evidence in Table 3). Lower-quality data or results from single centres were retained owing to the sparsity of available studies, especially in lumbar prosthesis. However, the aim was to collect the optimal evidence and build applicable recommendations for practice. Moreover, the SEC was able to report only partial or vague responses to the questions. This likely explains why the national PMR congress session did not obtain wide consensus between professionals. The first version of the recommendations resulted in discussion without full consensus. The votes and comments recorded during the congress improved the recommendations but did not reach consensus, which was only attained with the e-Delphi method [17], which is a reliable method for determining consensus in identifying and prioritising issues for decision-making. The main advantage of the e-Delphi is to include many anonymous experts across diverse locations and various health specialities, thus avoiding dominance of one individual or speciality. Usually, the number of rounds is defined at the start of the study, ranging from 2 to 3; 3 rounds were necessary for this e-Delphi, similar to others [18,74].

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Currently, only individual or team opinions are available on the Internet and rarely derived from methodologically sound studies, which probably explains their low application by physiotherapists or rehabilitation teams [20]. Pre-operative advice is mainly targeted for fusion and prosthesis such as radiculopathy to warn that discectomy may impede rehabilitation. Nevertheless, the importance of preparing patients for lumbar surgery is clearly described [75]. The valuable role of physical activities highlighted supports that pain impairs function and daily activities, which encourages physical activity very early in the care course: simply walking more the first week after lumbar surgery (disc and fusion) predicted lower disability at 6 months (Level 2) [53]. Moreover, high-intensity rehabilitation after all types of surgery is strongly supported by the literature [8,40,41,45,57] and is reflected here by the recommendations. The use of CBT is also supported by these recommendations, in line with the literature [24,76,77] and the French National Authority for Health (HAS) recommendations for LBP. More generally, this work reinforces the advice of active and multimodal rehabilitation after lumbar surgery [14]. The timing of the return to daily and physical activities is also stated with practical information for patients and professionals. These recommendations may lead to better consensual management and can help guide future studies.

Supporting the recommendations on timing of rehabilitation, a recent study confirmed that early rehabilitation after lumbar fusion leads to functional improvement and is safe [78]. Moreover, the recommendations provide some specific statements on movements, on activities needing precautions, and on corset use, for example. Although robust evidence is required to assist clinical practice, this large consensual approach is a vital first step to avoid uncertainty and align practice between healthcare professionals.

No safety issues should arise from these recommendations. First, the numerous recommendations concerning education give patients autonomy in movement recovery, preventing persisting disability and pain. Second, a reasonable level of evidence, notably in disc surgery, justifies the use of continued personalised physical activity, encourages (very) early empowerment, and limits restrictions after surgery [79]. These recommendations may help clinicians adjust their practice and provide a consensual basis for treatment limiting unwarranted restrictions to discuss useful implementations of rehabilitation in the care process. Undoubtedly, spine surgeons will adjust their practices according to surgical techniques and levels operated, which may lead to new studies and new recommendations in the next 10 years.

Adding interventions to surgical management may be cost-effective, although a recent report found no cost-effectiveness of referring patients to a physiotherapist after surgery for disc herniation [80]. Despite conflicting results, the general view seems to support education in lumbar fusion and partially in disc surgery. However, the education procedure is rarely isolated and is most often integrated in multimodal interventions combining various sorts of education, advice, and/or information). Therefore, these recommendations need to be tested in individual practice when structured education can be proposed.

LIMITATIONS

For several of the questions posed, no article in the literature addressed the issue (see Table 1). The available literature is skewed greatly toward disk surgery, with much less known on prosthesis.

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Therefore, recommendations for these areas are based solely on expert opinion. For other questions, the quality of the studies analysed was too poor to make any recommendations, for example, whether supervised rehabilitation was superior to non-supervised following discectomy. More large-scale, high-quality trials are required to expand and refine these recommendations.

The heterogeneity of results (from the literature), practices and opinions (meetings and e-Delphi procedure) may have influenced the recommendations, which reinforces the need for recommendations for practice. These recommendations should be considered as a first step toward consensual advice for practice and the basis for further studies answering questions not or only partially addressed in this work, as laid out in Table 1, in particular the risk:benefit ratio of complementary solutions in lumbar surgery and the reasons for choosing or avoiding postoperative rehabilitation.

The surgical techniques and material used in lumbar surgery change fast; thus recommendations are inappropriate because they quickly become irrelevant. In contrast, physiotherapy practices develop slowly, and recommendations made today are likely to remain in use for some decades. Indeed, when performing an updated literature search, few new studies were found in the previous 5 years that were relevant to the research question. These recommendations were developed in the context of French practices, but most if not all these recommendations can likely be directly applied to other countries.

RECOMMENDATIONS

Before surgery Recommendation 1: Educational care (reassurance, activities of daily living, neurophysiology of pain)* must be offered before lumbar surgery (Grade B for discectomy; Grade C for fusion and prosthesis). This education may be combined with specific exercises (strengthening, endurance, neuromotor reprogramming, stretching) before fusion surgery (Grade C) and prosthesis (Expert agreement).

* see French High Authority of Health recommendations.

Recommendation 2: Regular physical activity should be offered before lumbar surgery (fusion and prosthesis), 150 min per week*, prioritising independent activities personalised to the patient (Expert agreement).

*according to the World Health Organization (see www.who.int/news-room/fact-sheets/detail/physical-activity)

After surgery: general Recommendation 3: The purpose of rehabilitation after lumbar surgery is to reassure the patient; improve their mobility, functional capacities, and autonomy; and limit painful after-effects. It must be adapted to the physical and psychological condition of the patient, post-operative condition, professional and leisure activities (Expert agreement).

Recommendation 4: After lumbar surgery, a suitable exercise program (adapted to age, understanding, pain, abilities, and environment) and supervised, based on a booklet, an application or a website (preferably validated) should be offered to the patient (Grade C). This program should be performed or continued at home (Expert agreement).

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Recommendation 5: After lumbar surgery, patients should resume activities of daily living within the first 2 weeks postoperatively (Grade B for discectomy; Expert agreement for fusion and prosthesis), walk immediately and gradually introduce spine movements (Expert agreement).

Recommendation 6: After lumbar surgery, maintaining prolonged positions for long periods and movements and postures with the trunk in extreme positions are not recommended before 6 weeks (Expert agreement).

After discectomy Recommendation 7: After lumbar discectomy, initiation of rehabilitation adapted to the patient is recommended from 3 weeks after surgery (Expert Agreement) and from 4 to 6 weeks after surgery at the latest (Grade B).

Recommendation 8: After lumbar discectomy, rehabilitation offered should be adapted to the patient and of progressive intensity combined with behavioural approaches (discussion and sharing of experience between patients supervised by a professional, gradual exposure to movement, cognitive-behavioural therapies) (Grade C). Intense and dynamic active exercises (Grade A) should be proposed as a first-line choice, as opposed to isometric exercises or isolated stretching, which appear less effective (Grade B).

Recommendation 9: After lumbar discectomy, repetitive flexion exercises are not recommended before 6 weeks (Expert agreement).

After fusion Recommendation 10: After lumbar fusion, physiotherapist-led rehabilitation may be offered before the third month (Expert agreement). This rehabilitation can be intensified after the third month once healing is complete (Grade C), with the surgeon's agreement in an environment of support to achieve patient autonomy (Expert Agreement).

Recommendation 11: After lumbar fusion, behavioural approaches should be integrated into patient rehabilitation programs (discussions and sharing of experience between patients supervised by a professional, gradual exposure to movement, cognitive-behavioural therapies) (Grade B).

Recommendation 12: After lumbar fusion, repeated movements and postures with the trunk held in flexion are not recommended before 6 weeks (Expert agreement). Carrying heavy loads must be adapted before 3 months (Expert agreement).

After disc prosthesis Recommendation 13: After lumbar disc prosthesis, rehabilitation can be offered from the sixth postoperative week (Expert agreement). This rehabilitation can then be intensified and adapted to the patient's progress (Expert agreement).

Recommendation 14: After lumbar disc prosthesis, rehabilitation in forced extension and reinforcement in extension is not recommended before 6 weeks (Expert agreement).

After surgery: supplementary recommendations Recommendation 15: After lumbar surgery, exercise methods such as strengthening paravertebral muscles (especially the extensors), aerobic training (Grade C), pelvic and sub-pelvic stretching, increased mobility or neuromotor reprogramming can be implemented and adapted to the patient in the absence of contraindication (Expert agreement).

Recommendation 16: After lumbar surgery, the patient must continue a suitable, customised program, first supervised and then independently (Grade C for discectomy; Expert agreement for fusion and prosthesis). In a supervised program, patients can be given a sequence of exercises, advice for the

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gradual resumption of activities of daily living, support for the resumption of physical activities and sports, carried out in the presence of a physiotherapist in an institution or by a community physiotherapist during regular consultations (Expert agreement).

Recommendation 17: Educational interventions (structured information, discussion forum, therapeutic education, active educational interventions, "back-café") are an integral part of the care process and involve sharing of knowledge and/or experience (with other patients, an expert patient and/or a health or adapted physical activity professional) after lumbar surgery, regardless of the method used (Grade B).

Recommendation 18: Educational content for rehabilitation before or after lumbar surgery must be based on dedicated materials for low back pain (Back guide, before/after back surgery information booklet) with science- and/or practice-validated messages combined with information about the surgery (preparation, expectations of surgery, post-operative consequences) (Expert agreement).

Recommendation 19: After lumbar surgery, information diffusion by brochure or video alone is insufficient for patients with risk factors for chronicity (Grade C).

Recommendation 20: After lumbar surgery, wearing a corset or belt is only recommended on a case-by-case basis, based on the patient's pain and exposure to mechanical stresses, and should be for the minimum duration possible (Expert agreement).

Conclusions

These 20 recommendations provide the first tool to guide clinicians in the timing and choice of techniques/prescriptions. The recommendations may help patients and professionals discuss consensual ways to manage rehabilitation after low back surgery and encourage further research to improve practices supported by evidence.

Authors' contributions

The recommendation process was created and supervised by AD, PR, MMLC, PC, MG end EC. AD and SK drafted the first version of the manuscript. XD, CD, PK, EC, FR and PR contributed to the writing and the editing of the final version of the manuscript, which was approved by all the authors.

Ethics approval and consent to participate

Not applicable

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Declaration of Competing Interest

The authors who contributed significantly to the recommendations have declared their competing interest: Calmels Paul (consulting fees for Thuasne); Dufour Xavier (consulting for the French National Health Insurance, consulting fees for Thuasne); Coudeyre Emmanuel (consulting for Thuasne); Dupeyron Arnaud (consulting fees for Thuasne); Henrontin Yves (consulting fees for Thuasne); Kouyoumdjian Pascal (consulting fees for Stryker and Lepine, Designer for Euros); Rannou Francois: Consulting fees for low back¸ pain from the French High Authority of Health and the French National Health Insurance).

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.rehab.2021.101548.

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