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The clinical significance of redundant nerve roots of the cauda equina in lumbar spinal stenosis patients: A systematic literature review and meta-analysis

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ABSTRACT

Objectives: Decompression surgery for lumbar spinal stenosis (LSS) is the most performed spine surgery procedure in patients older than 65 years. Around 40% of LSS patients scheduled for decompression surgery have evidence of redundant nerve roots (RNR) of the cauda equina on their magnetic resonance images (MRI). Little is known about the clinical significance of RNR in LSS patients. The objective was to assess the effects of RNR on clinical scores and recovery in older adults diagnosed with LSS.

Patients and Methods: A systematic literature search was performed in April 2018 on PubMed, Web of Science, MEDLINE and Cumulative Index to Nursing and Allied Health Literature (CINAHL). Prospective and retrospective cohort studies undertaken to assess differences in clinical outcomes in patients diagnosed with LSS with versus without evidence of RNR on their MRIs were selected. Two authors independently selected studies, abstracted data and assessed risk of bias. We calculated weighted mean differences (WMD) for continuous variables and odds ratio (OR) for variables reported in frequencies.

Results: Seven studies comprising a total of 1046 LSS patients were included in the meta-analysis. LSS patients with evidence of RNR (RNR+) were older, WMD 5.7 95% CI [2.2–9.2], p = 0.001, had smaller cross sectional area (CSA) of the stenotic level, WMD −12.2 95% CI [−17.7 to −6.7], p < 0.0001 and longer symptom onset duration, WMD 13.2 95% CI [−0.2–26.7], p = 0.05. The pooled preoperative clinical score in the RNR + group was worse but the difference was not statistically significant, WMD −3.8 95% CI [−7.9 to 0.2], p = 0.07. After decompression surgery RNR + patients had worse clinical scores, −4.7 95% CI [−7.3 to −2.1], p = 0.0004 and lower recovery rates, −9.8 95% CI [−14.8 to −4.7], p = 0.0001.

Conclusion: There is limited quality evidence that RNR + patients are older, have a longer symptom history and present higher degrees of lumbar stenosis as given by the narrow CSA in comparison to RNR- patients. After decompression surgery RNR + patients have worse clinical scores and lower recovery rates. In view of these results RNR can be seen as a negative prognostic factor in LSS patients.

1. Introduction

Degenerative lumbar spinal stenosis (LSS) is a narrowing of the spinal canal with constriction of the neural structures by the surrounding bone and soft tissue. Depending on the location of the narrowing patients present neurogenic claudication symptoms (e.g. buttocks or leg pain while walking or standing that relieves with sitting or lumbar flexion) or radicular leg pain [1]. LSS is the most common reason for lumbar spine surgery in adults older than 65 years [2].

LSS patients with neurogenic claudication symptoms often present thickened, buckling, serpentine- or loop-shaped redundant nerve roots (RNR) on their T2-weighted sagittal or axial MRI slices. Studies have revealed that the prevalence rates of RNR among LSS patients can range from 33.8% to 43.3% [3–6].

1.1. Definition of redundant nerve roots

RNR were first described by Verbiest in 1954 [7] and were named later by Cressman and Pawl in 1968 [8]. In their case report the authors referred to the myelogram of a 67 years old patient, who showed

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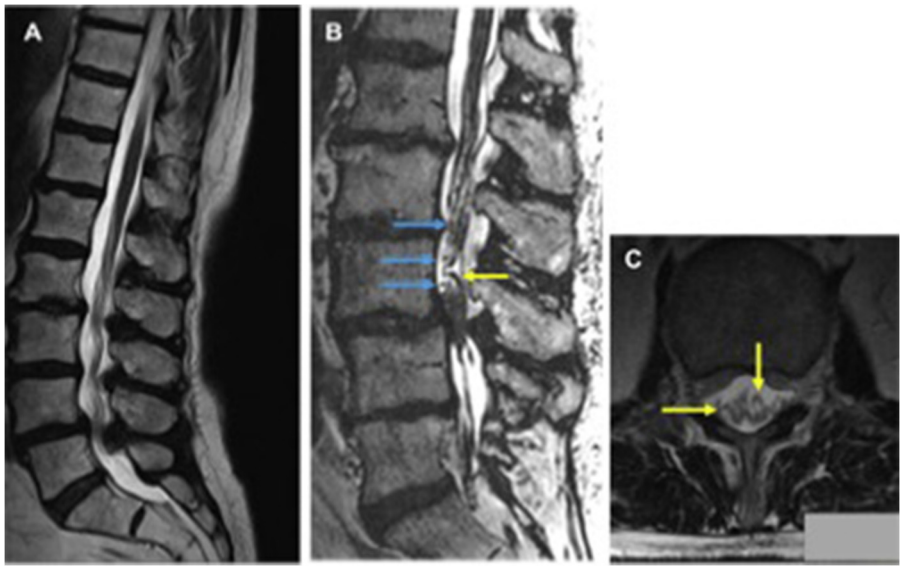

Fig. 1. Examples of serpentine- and loop-shaped RNR: (A) Sagittal T2-weighted MRI showing serpentine-shaped RNR; (B) loops as dots (blue arrows) or as a linear horizontal course of the root (yellow arrow); (C) T2-weighted axial slice showing horizontal roots, defined as loops (yellow arrows) (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

serpentine defects at L3/ L4 level with an almost complete block at L4/ L5 level. The authors reported that after the dura was opened "a markedly redundant nerve root, coiled upon itself in a serpentine manner" was visible [8]. In the decade after this first publication several case reports were published [9–14]. Neurogenic claudication was present in the history of most of the reported cases. Since advanced imaging techniques (CT, MRI) were not available by that time, RNR were only visible by means of myelography and were confirmed intraoperatively. In an anatomical study by Suzuki et al. [5] six specimen with evidence of RNR were investigated. The authors clearly stated that RNR are nerve roots that become elongated and thick through the constriction.

The development of computer tomography (CT), CT-myelography and magnetic resonance imaging (MRI) enabled the reliable diagnosis of RNR outside the operating room. Nowadays, lumbar sagittal and axial T2-weighted MRI slices are the most widespread examination for detecting RNR.

RNR can be described as "serpentines" when a sinusoidal deflection of the cauda equina nerve roots is observed on sagittal T2-weighted MRI slices without horizontalization (Fig. 1A). RNR can be defined as "loops" whenever the root has a fully horizontalized course, which can be visualized in the sagittal plane as either a linear horizontal course of the root (Fig. 1B) or as a dot sign corresponding to the right-left course of the orthogonal cut of the root (Fig. 1B) or as a straight line instead of a dot in the axial plane (Fig. 1C).

1.2. Why it is important to do this review

Little is known about the etiology and clinical significance of RNR of the cauda equina in LSS patients. Do LSS patients with evidence of RNR on their MRI differ from the ones without RNR in terms of time since the onset of symptoms, pre- and postoperative clinical scores and postoperative recovery? The objective of this meta-analysis is to investigate the effects of RNR on the clinical outcomes in LSS patients.

2. Materials and methods

2.1. Study design

This systematic review and meta-analysis was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement [15].

2.2. Criteria for considering studies for this review

Prospective or retrospective cohort studies in which LSS patients with evidence of RNR were compared to LSS patients with no evidence of RNR on their MRIs were considered. Older adults with clinical diagnosis of LSS were the target population out of which the study samples should consist.

The outcomes to be investigated were patient-specific variables (e.g. age, gender) and clinical variables (e.g. clinical scores before and after decompression surgery, time since the onset of symptoms, cross sectional area of the affected level and recovery rates).

2.3. Search methods for identification of studies

A systematic electronic database search was conducted on PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Web of Science and MEDLINE by one author (CJM) who received training from the Cochrane Collaboration at the Cochrane Center, Freiburg University, Germany. The first three databases were last searched on April 9th 2018; MEDLINE was last searched on April 16th 2018.

2.4. Search strategy

The search strategy used in PubMed is presented in Table 1. Different medical subject heading (Mesh) terms were used and combined.

Table 1
Search Strategy PubMed (last search on April 9th 2018).

Search	Term
#1	Spinal stenosis (Mesh)
#2	Lumbar vertebrae (Mesh)
#3	Intermittent claudication (Mesh)
#4	Cauda equina (Mesh)
#5	Polyradiculopathy (Mesh)
#6	Spinal nerve roots (Mesh)
#7	Nerve compression syndromes (Mesh)
#8	Spinal canal (Mesh)
#9	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8
#10	Redundant nerve root (full term)
#11	Redundant nerve roots (full term)
#12	RNR
#13	#10 OR #11 OR #12
#15	#10 AND #13