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SC Court of Appeals

THE STATE OF SOUTH CAROLINA
In The Court of Appeals

APPEAL FROM THE
SOUTH CAROLINA WORKER'S COMPENSATION COMMISSION

Gene McCaskill, Commissioner
R. Michael Campbell, II, Commissioner
T. Scott Beck, Commissioner

SCWCC File No. 1508995

Appellate Case No. 2018-001964

Samuel Paulino, Claimant — Respondent,

v.

Diversified Coatings, Inc., Employer, and AmGuard Ins. Co., Carrier — Appellant.

PETITION FOR REHEARING

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COMES NOW PLAINTIFF, by and through undersigned counsel, and files this, his Petition for Rehearing pursuant to Rule 221(a), SCACR, and in support of his Petition for Rehearing, Plaintiff respectfully submits the following as having been overlooked and/or misapprehended by the Court:

1. Although this Honorable Court states that the Commission erred in affirming the single commissioner's award of permanent total disability under the scheduled-member statute, the substantial evidence in the record supports the Commission's affirmation of the single commissioner's award of permanent and total disability under the scheduled member statute.
2. Although this Honorable Court states that the Commission erred in affirming the single commissioner's determination that the Claimant's back is impaired greater than fifty percent because there is no medical evidence in the record that supported the single commissioner's findings, there is substantial evidence in the record support the single commissioner's findings.
3. Although this Honorable Court states that the Claimant's treating physician, Dr. McHenry, reported that the Claimant's spine surgery was a success, there is no evidence in the record to support this Honorable Court's assertion that the Claimant's spine surgery was a success, and in fact, the record as a whole demonstrates anything but a successful surgical result.
4. Although this Honorable Court states that there is no evidence in the record indicating a poor surgical result and that as a result, the Commission erred in affirming the single commissioner's "medical opinion," to the contrary, there is indeed substantial evidence in the record to support a finding that the Claimant suffered a poor surgical result as

evidenced by the continued and persistent symptoms, limitations, restrictions, and difficulties Claimant suffered and continues to suffer following the surgical procedure to his spine.

5. Although this Honorable Court states that Claimant failed to rebut Dr. Math's twelve-percent impairment rating to his back with medical evidence, and therefore, the findings of fact adopted from the single commissioner's order are inconclusive, there is substantial evidence in the record to support the single commissioner's findings of fact as adopted by the Full Commission.

6. Although this Honorable Court states that the Claimant did not testify as to the character of his back injury, the specific ways his back injury prevents him from leading a normal life, and the limitations the back injury places on his physical activities, this Honorable Court seemingly overlooks the countless instances in which the medical evidence specifically documents and highlights the many ways that the Claimant's back injury prevents him from leading a normal life and the many the limitations that the back injury places on his physical activities.

7. Although this Honorable Court states that the Claimant failed to present evidence of a lower back impairment rating greater than twelve-percent and that substantial evidence does not support the Commission's finding as to the scheduled member, the is indeed substantial evidence in the record to support the Commission's finding as to the scheduled member.

WHEREFORE, Respondent requests that this matter be reexamined and reheard, and for any further relief this Court deems just and proper.

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March 22, 2022

Greenville, SC

MEMORANDUM

In support of his Petition for Rehearing, and pursuant to Rule 221(a), SCACR and Rule 240(c)(2), SCACR, Plaintiff respectfully submits the following as having been overlooked and/or misapprehended by the Court:

1. Although this Honorable Court finds that the Commission erred in affirming the Single Commissioner's award of permanent total disability under the scheduled-member statute, the substantial evidence in the record supports the Commission's affirmation of the Single Commissioner's award of permanent and total disability under the scheduled-member statute.
2. Although this Honorable Court finds that the Commission erred in affirming the Single Commissioner's determination that the Claimant's back is impaired greater than fifty percent because there is no medical evidence in the record that supported the single commissioner's findings, there is substantial evidence in the record to support the Single Commissioner's findings.
3. Although this Honorable Court finds that the Claimant's treating physician, Dr. McHenry, reported that the Claimant's spine surgery was a success, there is no evidence in the record to support this Honorable Court's assertion that the Claimant's spine surgery was a success, and in fact, the record as a whole demonstrates anything but a successful surgical result.
4. Although this Honorable Court finds that there is no evidence in the record indicating a poor surgical result and that as a result, the Commission erred in affirming the Single Commissioner's "medical opinion," to the contrary, there is indeed substantial *medical* evidence in the record to support a finding that the Claimant suffered a poor surgical

result as evidenced by the continued and persistent symptoms, limitations, restrictions, and difficulties Claimant suffered and continues to suffer following the surgical procedure to his spine.

5. Although this Honorable Court finds that Claimant failed to rebut Dr. Math's twelve-percent impairment rating to his back with *medical* evidence, and therefore, the findings of fact adopted from the Single Commissioner's order are inconclusive, there is substantial evidence in the record to support the Single Commissioner's findings of fact as adopted by the Full Commission.

6. Although this Honorable Court finds that the Claimant did not testify as to the character of his back injury, the specific ways his back injury prevents him from leading a normal life, and the limitations the back injury places on his physical activities, this Honorable Court seemingly overlooks the countless instances in which the *medical* evidence specifically documents and highlights the many ways that the Claimant's back injury prevents him from leading a normal life and the many the limitations that the back injury places on his physical activities.

7. Although this Honorable Court finds that the Claimant failed to present evidence of a lower back impairment rating greater than twelve-percent and that substantial evidence does not support the Commission's finding as to the scheduled member, there is indeed substantial evidence in the record to support the Commission's finding as to the scheduled member.

DISCUSSION

This Honorable Court has stated various findings and opinions that the undersigned now respectfully asserts are suggestive of the Court having misapprehended and/or overlooked specific points in the arguments of the parties and the Record on Appeal. The undersigned now argues that this Honorable Court, in making the aforementioned findings, (1) misapprehended and/or overlooked the medical evidence in the record as a whole, (2) misapprehended and/or overlooked the medical definition of surgical result or outcome, (3) misapprehended and/or overlooked the constraints placed on this Honorable Court by the standard of review, (4) misapprehended and/or overlooked S.C. Code Ann. 1-23-300(4) granting administrative agencies the statutory authority to utilize experience, technical competence, and specialized knowledge in the evaluation of evidence, and (5) that this Honorable Court is guilty of the same error of which it now accuses the Single Commissioner and Full Commission—adopting a medical opinion that is not supported by *any* evidence in the Record. The undersigned has stated the various findings that have been purportedly misapprehended and/or overlooked in chronological order in his Petition for Rehearing as well as at the onset of this Memorandum. However, for the purposes of continuity in arguments and/or positions, the undersigned will address these arguments without reference to their chronological appearance in this Honorable Court's Opinion.

3. **Although this Honorable Court states that the Claimant's treating physician, Dr. McHenry, reported that the Claimant's spine surgery was a success, there is no evidence in the record to support this Honorable Court's assertion that the Claimant's spine surgery was a success, and in fact, the record as a whole demonstrates anything but a successful surgical result.**

4. **Although this Honorable Court states that there is no evidence in the record indicating a poor surgical result and that as a result, the Commission erred in affirming the single commissioner's "medical opinion," to the contrary, there is indeed substantial evidence in the record to support a finding that the Claimant suffered a poor surgical result as evidenced by the continued and persistent symptoms, limitations, restrictions, and difficulties Claimant suffered and continues to suffer following the surgical procedure to his spine.**

This Honorable Court has singled out the Single Commissioner's finding (and the Full Commission's subsequent affirmation thereof) that "Claimant's impairment ratings are very low based on the poor surgical result" as having "particular significance." This Honorable Court further opined there is no evidence in the record that would indicate a poor surgical result to support such a finding by the Single Commissioner and affirmation by the Full Commission. In support of this opinion, this Honorable Court has pointed to three specific points: (1) that Dr. Math gave the only medical opinion regarding Claimant's impairment rating for his back and assigned a low back impairment of twelve percent, (2) Claimant's physical therapist opined that he could perform medium work duties that involved flexing and rotating his lumbar spine, (3) Claimant's treating physician and surgeon, Dr. McHenry, reported that Claimant's spine surgery "was a success" and the disc herniation and L3-L4 extrusion were no longer present, and (4) that Dr. McHenry stated a subsequent MRI showed no impingement on the Claimant's nerve that could cause leg pain. It is respectfully submitted that this Honorable Court has misapprehended and/or overlooked the medical evidence, medical opinions, layperson testimony, and standard of review.

Whether Dr. Math gave the only medical opinion regarding Claimant's impairment rating for his back and assigned a low back impairment of twelve percent.

Simply put, Dr. Math is *not* the only physician that stated their medical opinion regarding the Claimant's impairment rating to the back (twelve percent to the lumbar spine). In fact, on April 22, 2016, Dr. McHenry rated the Claimant at thirteen percent *to the whole person* while deferring to the Functional Capacity Evaluation on the issue of the Claimant's resultant restrictions and/or limitations.[1] Dr. Math indeed assigned a rating to the Claimant of twelve percent *to the lumbar spine* on December 6, 2017.[2] However, Defendants admitted that Claimant was "entitled to PPD compensation for loss of use of the back based on the thirteen-percent whole person impairment rating assigned by the treating neurosurgeon (Dr. McHenry)."[3] Defendants also admitted that Claimant had sustained a seventeen-percent regional impairment to the lumbar spine.[4] Defendants, on yet another occasion, admitted that Claimant had sustained a seventeen-percent impairment to the lumbar spine as per Dr. McHenry and a sixteen-percent impairment to the lumbar spine as per Dr. Math.[5] Defendants also admitted that the Claimant had sustained a "thirteen-percent whole person impairment rating which clearly converts under the AMA Guides, the multiplier factor that you use, that that translates into seventeen-percent."[6] Defendants further admitted that the Claimant had sustained a "seventeen-percent lumbar regional spine impairment

1 Appendix to Record on Appeal, pp. 91-92.
2 Appendix to Record on Appeal, pp. 280, 288.
3 Record on Appeal, p. 18, paragraph 2.
4 Record on Appeal, pp. 19 through 20.
5 Record on Appeal, p. 24, 2nd full paragraph; *see also* p. 25 and p. 26.
6 Appendix to Record on Appeal, p. 67, lines 11 through 15.

as the baseline."[7] Defendants, even further, admitted that "the rating was… seventeen percent."[8] Respectfully, this Honorable Court has misapprehended and/or overlooked the record as a whole in determining that the only medical opinion regarding the Claimant's impairment rating for his back originated from Dr. Math. Dr. McHenry's rating in conjunction with the admission(s) by the Defendants, denotes, at a minimum, competing medical opinions of twelve percent to the lumbar spine, thirteen percent to the lumbar spine, sixteen percent to the lumbar spine, and seventeen percent to the lumbar spine.

Whether Claimant's physical therapist opined that he could perform medium work duties that involved flexing and rotating his lumbar spine.

Respectfully, there is not a single medical note or opinion in the record as whole that originates from the *Claimant's* physical therapist stating that the Claimant could perform medium work duties. In fact, the Claimant attended twelve planned visits of physical therapy from September 3, 2015 to November 19, 2015 post-surgery.[9] The Claimant was discharged by his physical therapist with the assessment that he had "not progressed as anticipated and pain has been a limiting factor… even [in-clinic] PT has not been able to gain any increase[d] range."[10] Because this Honorable Court has not cited the Record in support of this highlighted finding of fact that Claimant's physical therapist opined that he could perform medium work duties, the undersigned operates under the assumption that in stating this finding of fact, this Honorable Court is referring to the Functional Capacity Evaluation performed on November 20, 2017.[11]

7 Appendix to Record on Appeal, p. 69, lines 6 through 8.
8 Appendix to Record on Appeal, p. 70, lines 20 through 21.
9 Appendix to Record on Appeal, p. 138 through 197.
10 Appendix to Record on Appeal, p. 192.
11 Appendix to Record on Appeal pp. 95 through 100, and Second Appendix to Record on Appeal pp. 2 through 4.

It should be noted that the Claimant testified that the *total amount of time* that he spent performing this Functional Capacity was approximately two hours and twenty minutes.[12] The Functional Capacity Evaluation, performed on November 20, 2017, was a focused evaluation aimed only at determining whether the Claimant had achieved maximum medical improvement[13] and to determine the Claimant's ability to return to work.[14] The Claimant did *not* receive treatment or recommendations from this physical therapist. The Claimant did *not* establish a long-standing relationship with this physical therapist, either. In essence, the physical therapist evaluated the Claimant over a two-hour-and-twenty-minute period and gave her opinion regarding the Claimant's physical demand capacity. It is respectfully submitted that this Honorable Court may have misapprehended and/or overlooked the nature of the relationship between the Claimant and the therapist that performed the Functional Capacity Evaluation, and in turn, misapprehended and/or overlooked the weight that should be given to the results/findings of Functional Capacity Evaluation itself.

It is also respectfully submitted that this Honorable Court may have overlooked the full opinion of the therapist that performed the functional capacity evaluation. This Honorable Court has stated, as fact, that the Claimant could perform medium work duties that involved flexing and rotating his lumbar spine. Again, because there is no specific citation of the Record to signal where this Honorable Court derived this stated fact, and although the undersigned does not agree that the Record supports such a finding of fact by this Honorable Court, the undersigned continues to operate under the aforementioned assumption that this Honorable Court is relying on page three (3) of the Second Appendix to the Record on Appeal. However, this very page specifically states

12 Appendix to Record on Appeal, p. 48, lines 10 through 12.
13 Appendix to Record on Appeal, p. 95, 276.
14 Appendix to Record on Appeal, p. 280.

that the Claimant "was noted to have decreased range of motion with lumbar/trunk rotational and flexion movements, and when lifting floor to waist with decreased body mechanics to decrease weight bearing on the [right lower extremity]…" The report also states that Claimant had max lumbar flexion of 50%, max lumbar extension of 50% and max thoracic rotation of 75% left and right.[15] Even further, the Claimant's physician, Dr. Math, evaluated the results of the Functional Capacity Evaluation and disagreed that the Claimant could return to work[16] and assigned permanent physical limitations of light work duty with no lifting of greater than ten pounds.[17] The Functional Capacity Evaluation Report is replete with statements that paint a much bleaker picture than that which this Honorable Court states as fact (i.e. the ability to perform medium work duties that involved flexing and rotating his lumbar spine). For instance, the report states:

- The Claimant "[a]mbulates with cane in his LEFT hand, decreased stances time on [right lower extremity], decreased [right] hip/knee flexion in swing phase, overall antalgic gait pattern."[18]

- Claimant "reported low back and hip pain with all MMT testing on R LE, and increased pain with MMT of Left Hip."[19]

- For the simple task of walking, "[a]erobic capacity was unable to be determined because of intense pain and antalgic gait on treadmill… patient was unable to tolerate the 5% grade and the minimum 2.0mph walking speed to complete the test. Pt was able to walk the 20min at 1.5mph with significant compensations… the following compensations were observed: decreased stance time on R LE creating asymmetrical stride length, decreased R hip/knee flexion in swing phase, labored breathing and mild sweating, forward flexed hip/trunk, B midfoot strike instead of heel strike, overall antalgic gait pattern, 8/10 low back pain reported after."[20]

- Claimant "required the use of [upper extremities] on chair to return to standing, multiple attempts made without use of furniture that results in short drop back

15 Appendix to Record on Appeal, p. 98.
16 Appendix to Record on Appeal, p. 280.
17 Appendix to Record on Appeal, p. 288.
18 Appendix to Record on Appeal, p. 97.
19 *Id.*
20 Appendix to Record on Appeal, p. 99.

> to ground, [Claimant] was only successful after using [upper extremities] on chair base to return to standing."[21]

This list is *not* exhaustive. The portions of the Record cited have even more detail regarding the Claimant's physical condition that directly contradicts the finding of fact by this Honorable Court that the Claimant could perform medium work duties that involved flexing and rotating his lumbar spine. Respectfully, it is submitted that this Honorable Court overlooked the Record as a whole—and even the essence of the Functional Capacity Evaluation itself—in finding as fact that the Claimant could perform medium work duties. Further, it is respectfully submitted that this Honorable Court overlooked and/or misapprehended the medical opinion of Dr. Math, who opined that the Claimant suffered permanent physical limitations of light duty with no lifting of greater than ten pounds irrespective of the findings contained within the Functional Capacity Evaluation.[22]

> **Whether Claimant's treating physician and surgeon, Dr. McHenry, reported that Claimant's spine surgery "was a success" and the disc herniation and L3-L4 extrusion were no longer present, and the implication of Dr. McHenry stating that a subsequent MRI showed no impingement on the Claimant's nerve that could cause leg pain.**

Respectfully, the undersigned is particularly and especially concerned that this Honorable Court has misapprehended and/or overlooked the evidence in the record as a whole in determining that Dr. McHenry "reported that the Claimant's spine surgery was a success and the disc herniation and L3-4 extrusion were no longer present." To the best of the undersigned's knowledge, the word "success" does not appear in the Record *at any time*, and certainly not for the purpose of describing

21 Appendix to Record on Appeal, p. 100.
22 Appendix to Record on Appeal, p. 288.

the Claimant's surgical result. To the contrary, the surgeon, Dr. McHenry, stated, "Patient is 8 weeks [status post] L3-4 microdiscectomy… patient has just not done as expected in the post-op period."[23] It is offered to this Honorable Court that the Record as whole is not consistent with this Court's finding that the Claimant's spine surgery was a success. It is also offered to this Honorable Court that that the finding that "a subsequent MRI showed no impingement" has no bearing whatsoever on whether the surgical procedure can be considered a success or failure. The undersigned further offers that the Record as a whole supports the Single Commissioner's finding and the Full Commission's affirmation that the Claimant suffered a "poor surgical result." The discrepancy between the undersigned's assertion and this Honorable Court's finding of fact and/or opinion appears to turn on the definition of "success" and the understanding of success criteria for surgical procedures.

Rule 201, SCRE allows for this Honorable Court to (1) take judicial notice of an adjudicative fact which is capable of accurate and ready determination by resort to sources whose accuracy cannot reasonably be questioned, (2) that such notice shall be taken if requested by a party and supplied with the necessary information, and (3) that judicial notice can be taken at any time of the proceeding. Insomuch as it is required by the Rule, Respondent respectfully requests that this Honorable Court take judicial notice that **the definition of "success" and/or "failure" of a surgical procedure's outcome or result is dependent on the outcome or result as it pertains to the patients *response* to the procedure**, and in support of this position, the Respondent offers three of the *many* articles readily available on the U.S. National Library of Medicine's various websites and repositories[24] and whose accuracy cannot reasonable be questioned, to wit:

23 Appendix to Record on Appeal, p. 116.
24 *See* www.ncbi.nlm.nih.gov; *See also* www.pubmed.ncbi.nlm.nih.gov.

- *Can We Define Success Criteria for Lumbar Disc Surgery?,* Acta Orthopaedica 2013; 84 (2): p. 196-201. **(Attached hereto as Exhibit A.) (“**There is no well-defined gold standard for defining a successful outcome, but most clinicians and researchers agree that change of scores on a validated *patient-reported* outcome should not only reflect a statistically significant change, but also a change that is sufficiently large to be of clinical importance *to the patient*… Success indicates an improvement that reflects a substantial amount of change rather than a minimal amount of change… We defined the patients who reported that they were completely recovered or much improved to represent success.”)

- *Prospective Multiple Outcomes Study of Outpatient lumbar microdiscectomy: should 75% to 80% success rates be the norm?*, J Neurosurg. 2002 Jan; 96 (1 Suppl):34-44. **(Attached hereto as Exhibit B.)** (Successful outcome rates were as follows: leg pain relief according to a visual analog scale (VAS), 80%; back pain relief (VAS), 77%; Oswestry Low Back Disability Index, 78%; satisfaction with the results of surgery, 76%; return to normal daily activities, 65%; and return to work, 61%.)

- *Risk Factors for Poor Outcome of Surgery for Cervical Spondylotic Myelopathy*, Spinal Cord (2016) 54, 1127-1131. **(Attached hereto as Exhibit C.)** (“The purpose of this study was to characterise risk factors for poor surgical outcomes… Japanese Orthopaedic Association (JOA) score recovery rate of <50% was defined as poor surgical outcome.”)

Note that the common theme among these cited clinical studies is that success or failure of a surgical outcome (*or result*) is measured by the individual patient’s response to the procedure and *not* whether the procedure itself was correctly completed. Even if this Honorable Court does not want to accept the aforementioned definition of “success” within the context of surgical outcomes (or results) by reference to cited studies, then I would respectfully request that this Honorable Court take notice of the plain meaning of the Single Commissioner’s and the Full Commission’s intended use of the word “result”. Merriam-Webster defines “result” (noun) as “something that results as a consequence, issue, or conclusion.” Respectfully, it is far more reasonable to conclude, that by the use of the word “result”, the Single Commissioner and Full Commission were concerned with the “result” as it pertained to the alleviation of the Claimant’s symptoms and not as it pertained to whether the surgical procedure successfully removed the

compression from the Claimant's nerve.

In applying the aforementioned definition(s) to the Claimant's surgical outcome (or result), it is clear that the Claimant indeed suffered a "poor surgical result" as found by the Single Commissioner and affirmed by the Full Commission. Respectfully, there is little, if anything, in the Record to support any other finding. In fact, from a logical standpoint, it simply would not be reasonable to interpret the Single Commissioner's and the Full Commission's finding that the Claimant suffered a poor surgical result as anything but that the Claimant's *outcome* was poor based on the continued difficulties and permanent nerve damage that the Claimant suffers.

This Honorable Court's Opinion appears to infer that because Dr. McHenry, in reviewing the MRI performed on February 15, 2017, opined that the disc herniation and extrusion at L3-4 is no longer present, *that therefore*, the surgical result was successful. Not only is that a misapprehension of the clinical definition of "success" or "failure" of a surgical procedure, but more importantly, that is a clear misapprehension of the purpose of the MRI study altogether. The purpose of the study was to determine whether the Claimant would benefit from further surgical intervention.[25] Because the MRI did not show any further compression of the spine that would alleviate symptoms, a second surgery was not recommended. However, that is *not* evidence of a successful surgical outcome or result.

That leads us to the discussion regarding the Claimant's permanent nerve damage and the inferences made by this Honorable Court. This Honorable Court's finding(s) appears to infer that because Dr. McHenry opined that the MRI showed no impingement on the Claimant's nerve that could cause leg pain, that somehow, that opinion suggests that either the Claimant had a successful

25 Appendix to Record on Appeal, p. 131 ("I do not think [Claimant] would benefit from further surgical intervention.")

surgical result, that the Claimant no longer suffered the symptoms and/or condition (radiculopathy) that hoped to be resolved by the surgical procedure, or both. Again, that is a clear misapprehension in the understanding of the definition of success or failure of a surgical procedure, and more importantly, that is a clear misapprehension of Dr. McHenry's stated opinion. Dr. McHenry wanted to determine whether any further surgical intervention was indicated. We have already established, Dr. McHenry opined that the Claimant would not benefit from further surgical intervention.[26] However, what appears to be overlooked is that Claimant suffered permanent nerve root damage as a result of the previously existent nerve root impingement that was corrected by the L3-4 laminectomy performed in July of 2015. The medical evidence in the Record supports the position that Claimant suffered permanent nerve root damage irrespective of whether the MRI performed on February 15, 2017 showed that the L3-4 extrusion was no longer present, to wit:

- Dr. McHenry continued to prescribe **neuropathic pain medication** to help control the symptoms associated with the Claimant's permanent nerve damage.[27]

- Dr. McHenry noted "straight leg raise positive on the right with radicular pain to the foot."[28]

- Dr. Math opined that Claimant would require chronic pain management in the form of pain medication. **Neuropathic medication**, muscle relaxants,. Interventions, like epidural steroid injection. **He may also be candidate for spinal cord stim P for his chronic right radiculopathy**.[29] (Emphasis added.)

- Dr. McHenry never once questioned the origin of the Claimant's continued radicular symptoms—and quite frankly, *not a single medical provider questioned the Claimant's honesty or credibility regarding his presentation of pain… and neither did the Commission…* ***and neither did the Defendants.***

26 Appendix to Record on Appeal, p. 131 ("I do not think [Claimant] would benefit from further surgical intervention.")
27 Appendix to Record on Appeal, p. 131.
28 Appendix to Record on Appeal, p. 131.
29 Appendix to Record on Appeal, p. 280.

Insomuch as this Honorable Court's Opinion infers that because Dr. McHenry opined that the MRI showed no impingement on the Claimant's nerve that could cause leg pain, therefore, the Claimant had a successful surgical result and/or that the Claimant no longer suffered the symptoms and/or condition (radiculopathy) that was expected to be resolved by the surgical procedure, it is respectfully submitted that this Honorable Court may have misapprehended or overlooked the record as a whole in reaching said finding.

The Single Commissioner and Full Commission, by way of affirmation, relied on substantial evidence in the record as a whole to support the finding that the Claimant suffered a poor surgical result. This finding was not merely an opinion based on surmise, conjecture, or speculation, but arguably, an unopposed, medical fact. The undersigned recognizes that this Honorable Court may have their own opinion regarding the interpretation of the evidence in the record, however, under the substantial evidence standard of review, this Court may not substitute its judgment for that of the Commission as to the weight of the evidence on questions of fact, but may only reverse where the decision is affected by an error of law.[30] In the instant matter, although the Claimant argues that there is no evidence in the Record to support a finding by this Honorable Court that the Claimant's surgical outcome was successful, even if there was evidence to that effect, there is *also* substantial evidence in the record to support a finding that the Claimant suffered a poor surgical result. Even if this Honorable Court disagrees with the Single Commissioner and the Full Commission as to the finding that the Claimant suffered a poor surgical result, this Honorable Court is bound by the standard of review and may not substitute its judgment for that of the Full Commission. Even more so, it is respectfully submitted that by finding that

30 *Potter v. Spartanburg School District*, 395 S.C. 17, 22, 716 S.E.2d 123, 126 (Ct.App. 2011)(*citing Stone v. Traylor Bros.*, 360 S.C. 271, 274, 600 S.E.2d 551, 552 (Ct. App. 2004).

that the Claimant's surgery was "successful", this Honorable Court is guilty of the same error of which it now accuses the Single Commissioner and Full Commission—adopting a medical opinion that is not supported by *any* evidence in the Record. There is not a single medical provider nor is there single scintilla of evidence in the record to support a finding that the Claimant's surgical procedure was successful—by any metric.

5. **Although this Honorable Court states that Claimant failed to rebut Dr. Math's twelve-percent impairment rating to his back with medical evidence, and therefore, the findings of fact adopted from the single commissioner's order are inconclusive, there is substantial evidence in the record to support the single commissioner's findings of fact as adopted by the Full Commission.**

6. **Although this Honorable Court states that the Claimant did not testify as to the character of his back injury, the specific ways his back injury prevents him from leading a normal life, and the limitations the back injury places on his physical activities, this Honorable Court seemingly overlooks the countless instances in which the *medical evidence* specifically documents and highlights the many ways that the Claimant's back injury prevents him from leading a normal life and the many the limitations that the back injury places on his physical activities.**

7. **Although this Honorable Court states that the Claimant failed to present evidence of a lower back impairment rating greater than twelve-percent and that substantial evidence does not support the Commission's finding as to the scheduled member, there is indeed substantial evidence in the record to support the Commission's finding as to the scheduled member.**

It is respectfully submitted that this Honorable Court misapprehended or overlooked the Record as a whole in finding that the "Claimant failed to rebut Dr. Math's twelve-percent rating to his back with medical evidence" and that the Single Commissioner's finding and Full Commission's affirmation is inconclusive. In reaching this finding, this Honorable Court appears to dismiss the medical evidence within the Record, but leaves the door open for the possibility that Dr. Math's twelve-percent rating can be rebutted with layperson testimony. Although this Honorable Court eventually goes on to find that the Claimant's lay testimony does *not* rebut Dr.

Math's twelve-percent rating, the Court *does* cite various examples of relevant layperson testimony that could be used to rebut the medical evidence in the Record, to wit:

- Where Claimant testified exclusively to the pain associated with his injury and the burden it placed on his daily activities;
- Compensation is based solely on the character of the injury and not upon the earnings or earning capacity of the injured employee;
- The issue under the scheduled-member statute is not impairment as to the whole body, but rather it is the loss of use of a specific body part;
- The specific ways a Claimant's back injury prevents him from leading a normal life; and
- The limitations the back injury places on the Claimant's physical activities;

This Honorable Court found that the Claimant to failed to present evidence in the form of layperson testimony that highlighted the aforementioned points so as to rebut Dr. Math's twelve-percent rating to the back. This Honorable Court further found that the Claimant failed to present evidence of a lower back impairment rating greater than twelve percent, and as a result, substantial evidence does not support the Commission's finding as to the scheduled member of a lower back impairment rating of greater than twelve-percent.[31] It is respectfully submitted that this Honorable Court has misapprehended and/or overlooked the *medical evidence* in the Record as a whole that specifically addresses the very examples that this Court found was *not* presented as layperson testimony. In addressing the aforementioned medical evidence that this Honorable Court has opined was *not* offered as layperson testimony, I will limit the discussion to only those subjective

31 Note that Claimant, within this Petition and Memorandum, has already argued that the evidence establishes that there were competing ratings of twelve percent, thirteen percent, sixteen percent, and seventeen percent.

and objective observations and opinions within the Record regarding the Claimant's limitations that prevent him from living a normal life and that are noted *after* the date of maximum medical improvement. In doing so, the inference is that any continuing said issues, limitations, and restrcitions existed at the time that the Single Commissioner and Full Commission made their findings.

On the Claimant's last visit with the surgeon, Dr. McHenry, various observations, both objective and subjective, were noted in the medical notes: (1) positive for activity change and fatigue, (2) positive for shortness of breath, (3) positive for palpitations, (4) positive for difficulty urinating, (5) positive for back pain and gait problems, (6) positive for sleep disturbances and dysphoric mood, (7) sitting straight leg raise positive on the right with radicular pain to the foot, (8) leg pain, right, (9) pain of back and right lower extremity, (10) muscle weakness, (11) difficulty walking, (12) back stiffness, and (13) chronic low back pain.[32] On the Claimant's last visit in the Record with the pain management physician, Dr. Math, various observations, both objective and subjective, were noted in the medical notes: (1) patient reports that he tried his best during the FCE, but the pain aggravated after the FCE was completed for next couple of days is afraid he cannot go back to work, (2) patient reports persistent pain in the right lower extremity in L5 distribution, (3) patient reports that his pain is activity limiting, (4) patient feels his pain is not adequately controlled, (5) patient is concerned that he is not able to participate in his daily activities due to the pain, (6) considering the duration of the pain, most likely he will have chronic pain issues (tearful when discussing), (7) pain score of 6 (scale of 1-10), (8) pain limitations: general activity, (9) pain interventions: medications, (10) exhibits tenderness on musculoskeletal examination, (11) ambulates with cane, (12) has decreased stance and right lower extremity

32 Appendix to Record on Appeal, pp. 130 through 134.

Lumbar flexion is up to 40-50º lumbar extension is 5º causes severe pain, (13) tenderness over right lower lumbar paraspinal muscles, (14) reflexes 1+ at bilateral knee symmetrically absent at ankle, (15) plantars are downgoing, (16) straight leg test causes pain at the back of the knee, (17) slightly impaired sensation on the lateral border of the right foot, (18) will require chronic pain management in the form of pain medication, neuropathic medication, muscle relaxants, epidural steroid injections, (19) candidate for spinal cord stimulator for chronic right radiculopathy, and (20) permanent physical limitations of no lifting greater than 10 pounds.[33] The Claimant's Functional Capacity Evaluation is even more indicative of the how the Claimant's injury prevents him from leading a normal life and the limitations that the injury has placed on his daily activities (and although some of these limitations have already been highlighted in this memorandum, it deserves repeating, while keeping in mind that these are *all* observations of the evaluator and *not* subjective complaints by the Claimant): (1) ambulates with cane in LEFT hand, (2) decreased stance time on right lower extremity, (3) decreased right hip/knee flexion in swing phase, (4) overall antalgic gait pattern, (5) lumbar flexion of 50%, (6) lumbar extension of 50%, (7) thoracic rotation left and right of 75%, (8) aerobic capacity unable to be determined because of intense pain and antalgic gait on treadmill, (9) unable to tolerate 5% grade and minimum 2.0 MPH walking speed to complete test, (10) able to walk 1.5 MPH with significant compensations, (11) decreased stance time on right lower extremity creating asymmetrical stride length, (12) decreased right hip and knee flexion in swing phase, (13) labored breathing, (14) forward flexed hip and trunk, (15) bilateral midfoot strike instead of heel strike, (16) overall antalgic gait pattern, (17) 8/10 low back pain reported after walking test, (18) frequent weight shift on the left side, (19) numbness down right lower extremity to foot as standing progressed, (20) weight shifted on left side with overhead

33 Appendix to Record on Appeal, pp. 277 through 288.

activity, (21) heavy wight shift onto left lower extremity while lifting floor to waist, (22) increased trunk and hip flexion while lifting floor to waist, (23) increased extension to low back with waist to overhead lifting, (24) decreased lumbar curve reversal with 20 repetitions of lumbar flexion, (25) hands reached only top of shit with repetitive lumbar flexion, (26) only able to rotate 75% lumbar range of motion, (27) elbows extended with double carry of 100 feet, (28) increased lumbar extension with double carry of 100 feet, (29) mild labored breathing with double carry of 100 feet, (30) required use of upper extremities on chair to return to standing, (31) multiple attempts to return to standing without use of furniture resulted in a short drop back to the ground, (32) patient was only successful in returning to standing after using upper extremities on chair base to return to standing, (33) 6/10 low back pain reported after transfer test, (34) high pain focus noted according to Million Visual Analog Scale, (35) decreased range of motion noted with lumbar and trunk rotational and flexion movements, (36) decreased body mechanics to decrease weight bearing on right lower extremity when lifting floor to waist, (37) aerobic capacity was unable to be determined due to inability to complete test due to safety concerns associated with antalgic gait pattern while walking at the required speed and incline.[34] With reference to just three medical notes totaling just twenty three pages—of a Record that contains nearly one hundred fifty pages of medical notes—the Claimant has identified seventy separate points of medical evidence that specifically demonstrates the character of the Claimant's back injury (painful, limited range of motion, etc.), the specific ways his back injury prevents him from leading a normal life (labored breathing, difficulty standing, shortness of breath, limited range of motion, high pain focus, etc.), and the limitations the back injury places on his physical activities (difficulties with even slow

34 Appendix to Record on Appeal, pp. 95 through 100; *see also* 2nd Appendix to Record on Appeal pp. 3 and 4.

walking, no lifting of greater than 10 pounds without significant pain, antalgic gait, altered heel strike, etc.).

Following its finding that (1) the Claimant has failed to present layperson testimony rebutting the 12-percent impairment assigned by Dr. Math, and further, (2) following its finding that the Claimant has failed to testify as to the specific ways his back injury prevents him from leading a normal life and the limitations the back injury places on his physical activities, and finally, (3) following its finding that Claimant failed to rebut Dr. Math's 12-percent rating with medical evidence, it is respectfully submitted that this Honorable Court has misapprehended and/or overlooked the medical evidence in the Record as a whole.

1. **Although this Honorable Court states that the Commission erred in affirming the single commissioner's award of permanent total disability under the scheduled-member statute, the substantial evidence in the record supports the Commission's affirmation of the single commissioner's award of permanent and total disability under the scheduled member statute.**
2. **Although this Honorable Court states that the Commission erred in affirming the single commissioner's determination that the Claimant's back is impaired greater than fifty percent because there is no medical evidence in the record that supported the single commissioner's findings, there is substantial evidence in the record support the single commissioner's findings.**

It is respectfully submitted that this Honorable Court may have misapprehended or overlooked the standard of review in the instant matter in the above findings. Again, the undersigned recognizes that this Honorable Court may have their own opinion regarding the interpretation of the evidence in the record, however, under the substantial evidence standard of review, this Court may not substitute its judgment for that of the Commission as to the weight of the evidence on questions of fact, but may reverse where the decision is affected by

an error of law.[35] In a workers' compensation case, this Honorable Court does not have the authority to find facts; that authority belongs to the Commission.[36] As a general rule, this Court must affirm the findings of fact made by the Commission if they are supported by substantial evidence.[37] This Honorable Court has cited the exception to this rule that, where no evidence indicates a medical opinion or finding of fact of a single commissioner originated from a medical provider, such an opinion or finding is not supported by substantial evidence, however, that exception does not arise in this case. While the undersigned does not purport to place himself in the collective mind of this Honorable Court, the underlying theme of this Court's opinion appears to be that the Court simply does not agree that the Claimant has suffered a greater than 50% disability to his spine. However, the possibility of drawing two inconsistent conclusions from the evidence does not prevent the Commission's finding from being supported by substantial evidence.[38]

It is also respectfully submitted that this Honorable Court has overlooked S.C. Code Ann. § 1-23-330(4) regarding evidentiary matters in contested cases. Specifically, this Court overlooks the Commission's experience, technical competence, and specialized knowledge in the evaluation of evidence. S.C. Code Ann. § 1-23-330(4) reads in pertinent part, "The agency's experience, technical competence and specialized knowledge may be utilized in the evaluation of evidence."

The Commission, collectively, has spent countless hours, weeks, and even years evaluating

35 *Potter v. Spartanburg School District*, 395 S.C. 17, 22, 716 S.E.2d 123, 126 (Ct.App. 2011)(*citing Stone v. Traylor Bros.*, 360 S.C. 271, 274, 600 S.E.2d 551, 552 (Ct. App. 2004).
36 *Burnette v. City of Greenville*, 401 S.C. 417,429, 737 S.E.2d 200, 206 (Ct. App. 2012); *citing Sigmon v. Dayco Corp.*, 316 S.C. 260, 262, 449 S.E.2d 497, 498 (Ct. App. 1994).
37 *Id.* at 427, 205.
38 *Burnette v. City of Greenville*, 401 S.C. 417,427, 737 S.E.2d 200, 205 (Ct. App. 2012).

medical records and evidence. The Commission scours medical records searching for bits and pieces of evidence to support their decisions, and ultimately, to make findings and conclusions that are fair and supported by substantial evidence. Throughout that process, the Commission gains experience, technical competence, and specialized knowledge of the terms and definitions used within the medical community (*including, for example, the definition of "surgical outcomes and results"*). It is respectfully submitted that this Honorable Court has overlooked the statutory authority of the Commission to avail themselves of their experience, technical competence and specialized knowledge in the evaluation of medical records as wells as the medical evidence as a whole. Quite frankly, the Commission deserves far more deference than it was afforded in the instant matter.

CONCLUSION

It is respectfully submitted that this Honorable Court has misapprehended and/or overlooked the substantial evidence in the record as a whole in support of the Single Commissioner's and the Full Commission's Findings as well as the constraints imposed by the relevant standard(s) of review. It is also respectfully submitted that this Honorable Court misapprehended and/or overlooked the constraints of the relevant standard(s) of review in reaching its findings. Respondent requests that this matter be reexamined and reheard, and for any further relief the Court deems just and proper.

(SIGNATURE ON FOLLOWING PAGE)

Respectfully submitted,

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Can we define success criteria for lumbar disc surgery? : estimates for a substantial amount of improvement in core outcome measures

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Abstract

Background and purpose: A successful outcome after lumbar discectomy indicates a substantial improvement. To use the cutoffs for minimal clinically important difference (MCID) as success criteria has a large potential bias, simply because it is difficult to classify patients who report that they are "moderately improved". We propose that the criteria for success should be defined by those who report that they are "completely recovered" or "much better".

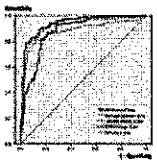
Methods: A cohort of 692 patients were operated for lumbar disc herniation and followed for one year in the Norwegian Registry for Spine Surgery. The global perceived scale of change was used as an external criterion, and success was defined as those who reported that they were "completely recovered" or "much better". Criteria for success for each of (1) the Oswestry disability index (ODI; score range 0-100 where 0 = no disability), (2) the numerical pain scale (NRS; range 0-10 where 0 = no pain) for back and leg pain, and (3) the Euroqol (EQ-5D; -0.6 to 1 where 1 = perfect health) were estimated by defining the optimal cutoff point on receiver operating characteristic curves.

Results: The cutoff values for success for the mean change scores were 20 (ODI), 2.5 (NRS back), 3.5 (NRS leg), and 0.30 (EQ-5D). According to the cutoff estimates, the proportions of successful outcomes were 66% for the ODI and 67% for the NRS leg pain scale.

Interpretation: The sensitivity/specificity values for the ODI and leg pain were acceptable, whereas they were very low for the EQ-5D. The cutoffs for success can be used as benchmarks when comparing data from different surgical units.

Figures

A1



ROC curves for Oswestry disability index (ODI),...

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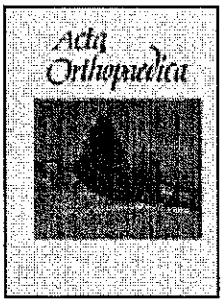

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Estimates for a substantial amount of improvement in core outcome measures

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Can we define success criteria for lumbar disc surgery?

Estimates for a substantial amount of improvement in core outcome measures

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Background and purpose A successful outcome after lumbar discectomy indicates a substantial improvement. To use the cutoffs for minimal clinically important difference (MCID) as success criteria has a large potential bias, simply because it is difficult to classify patients who report that they are "moderately improved". We propose that the criteria for success should be defined by those who report that they are "completely recovered" or "much better".

Methods A cohort of 692 patients were operated for lumbar disc herniation and followed for 1 year in the Norwegian Registry for Spine Surgery. The global perceived scale of change was used as an external criterion, and success was defined as those who reported that they were "completely recovered" or "much better". Criteria for success for each of (1) the Oswestry disability index (ODI; score range 0–100 where 0 = no disability), (2) the numerical pain scale (NRS; range 0–10 where 0 = no pain) for back and leg pain, and (3) the Euroqol (EQ-5D; –0.6 to 1 where 1 = perfect health) were estimated by defining the optimal cutoff point on receiver operating characteristic curves.

Results The cutoff values for success for the mean change scores were 20 (ODI), 2.5 (NRS back), 3.5 (NRS leg), and 0.30 (EQ-5D). According to the cutoff estimates, the proportions of successful outcomes were 66% for the ODI and 67% for the NRS leg pain scale.

Interpretation The sensitivity/specificity values for the ODI and leg pain were acceptable, whereas they were very low for the EQ-5D. The cutoffs for success can be used as benchmarks when comparing data from different surgical units.

Rates of successful outcome after surgical treatment of lumbar disc herniation vary and are influenced by the measurement scale or instrument that is used, definition(s), and cutoffs of the actual outcome (Greenough 1993, Asch et al. 2002, Copay et al. 2008, 2010). There is no well-defined gold standard for defining a successful outcome, but most clinicians and researchers agree that change of scores on a validated patient-reported outcome such as the Oswestry disability index (ODI) (Fairbank et al. 1980) and pain scales (Jensen and Karoly 1992) should not only reflect a statistically significant change, but also a change that is sufficiently large to be of clinical importance to the patient (Copay et al. 2007, Terwee et al. 2007). The minimal clinically important difference (MCID) has been defined as "the smallest difference in score in the domain of interest which patients perceive as beneficial and would mandate, in the absence of troublesome side effects and excessive cost" (Jaeschke et al. 1989). The cutoff for the MCID (external criterion or anchor) is usually defined on a self-reported global perceived health-effect scale. It has also been suggested that this method be used to define evidence-based criteria for successful outcomes after spine surgery (Copay et al. 2007). Such success criteria would be valuable for spine surgery registries in comparing effectiveness of treatment over time and between surgical units.

Conceptually, there is a difference between the MCID and success. Success indicates an improvement that reflects a substantial amount of change rather than a minimal amount of change. A source of bias is attached to estimates of minimal amount of change, simply because it is difficult to judge whether patients who report themselves to be "slightly" or "moderately" improved have had a change that one can consider to be important. One simple way around this obstacle is to provide estimates of success that include only patients with a substantial amount of change, defined by self-reports of "completely recovered" or "much better".

We estimated cutoff values for success criteria for the (ODI), the numerical pain scale (NRS) for back and leg pain, and the Euroqol (EQ-5D) in patients who were operated for lumbar disc herniation.

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Patients and methods

Study population

Data for this cohort study were collected through the Norwegian Registry for Spine Surgery (NORspine), which started in 2006 and is a comprehensive clinical registry for quality control and research. This study covered the first 692 consecutive patients who were operated for lumbar disc herniation at 16 surgical units in Norway and who were included in the registry during the implementation period between October 2006 and March 2008. Follow-up time from the date of the operation (baseline) was 12 months.

Informed consent was obtained from all participants. The registry protocol was approved by the Data Inspectorate of Norway.

Patient-reported outcome measures

All questionnaires were self-administered and were identical at baseline and follow-up.

Functional status was assessed by the Oswestry low back disability questionnaire (ODI) (Fairbank et al. 1980), which contains 10 questions on limitations of activities of daily living. Each variable is rated on a 0- to 5-point scale, added up, and converted into a percentage score. The range of possible values is from 0 to 100 (where 0 = no disability).

Intensity of pain was graded in 2 separate 0–10 numerical rating scales (NRS) for back pain (NRS back) and leg pain (NRS leg) where 0 = no pain (Jensen and Karoly 1992).

EQ-5D is a generic and preference-weighted measure of health-related quality of life (HRQL) (The EuroQol Group 1990). It evaluates 5 dimensions: mobility, self-care, activities of daily living, pain, and anxiety and/or depression. For each dimension, the patient describes 3 possible levels of problems (none, mild-to-moderate, and severe). This descriptive system therefore contains $3^5 = 243$ combinations or index values for health status. We used the value set based on the main survey from the EuroQol group (Dolan et al. 1996), which has been validated for patient populations similar to that in our study (Solberg et al. 2005). Total score ranges from –0.6 to 1, where 1 corresponds to perfect health and 0 to death. Negative values are considered to be worse than death.

These instruments—the NRS pain scales, ODI, and EQ-5D—have shown good validity and are frequently used in research on back pain. The Norwegian versions of these instruments have shown good psychometric properties (Grotle et al. 2003, Solberg et al. 2005). The questionnaire at follow-up included a global question about the patient's perception of change during the follow-up period (Kamper et al. 2010). The responses were assessed on a 7-point scale: 1 = completely recovered, 2 = much improved, 3 = slightly improved, 4 = no change, 5 = slightly worse, 6 = much worse, and 7 = worse than ever.

Data collection and registration by the NORspine registry protocol

At admission for surgery, the patient completed the baseline questionnaire, which included questions about demographics and lifestyle issues in addition to the outcome measures. During the hospital stay, using a standard registration form, the surgeon recorded data concerning diagnosis, employment status, duration of symptoms, and treatment.

12 months after surgery, a questionnaire was distributed by regular post, completed at home by the patients, and returned in the same way. 1 reminder with a new copy of the questionnaire was sent to those who did not respond.

Statistics

All statistical analyses were performed with SPSS for Windows version 14.0. Baseline and 1-year scores were compared with paired-samples t-test. Mean change scores between the subgroups were analyzed with one-way ANOVA. Spearman rank correlation coefficient was used to assess the relationship between the global change scale and the change scores of the instruments.

Cutoff values for success

The global perceived change scale was used as the anchor or external criterion for defining a successful outcome 1 year after surgery (Kamper et al. 2010). We defined the patients who reported that they were completely recovered or much improved (categories 1 and 2) to represent success, whereas those who reported themselves as being slightly improved, having no change, or being slightly worse (categories 3–5) were considered to represent no success. Since few patients reported that they were much worse or worse than ever (categories 6–7), we could not establish a subgroup with deterioration.

The change scores were calculated by subtracting the baseline score from the follow-up score. The mean change scores in the instruments were compared to the categories in the anchor by using ANCOVA (General Linear Model) with adjustment for baseline scores. The relationship between change scores and the external criterion was calculated using Spearman rank correlation coefficient.

A receiver operating characteristic (ROC) curve was obtained by plotting every possible cutoff score's sensitivity on the y-axis against 1 – specificity on the x-axis. Sensitivity was defined as the proportion of patients who were correctly classified in the success group, whereas specificity was defined as the proportion of patients who were correctly classified in the no-success group. To determine the optimal cutoff score for successful outcome, the point closest to the upper-left corner of the ROC curve was used, which is assumed to be the best cutoff score to distinguish between success or not, as it represents the lowest overall misclassification. We defined the most optimal cutoff point by looking at the sensitivity and specificity for various cutoff values and the percentage of

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Table 1. Characteristics of the study population (n = 692) at baseline

Mean age (SD)	46 (13)
Females, n (%)	284 (41)
Smokers, n (%)	228 (33)
University or college education, n (%)	228 (33)
Received social benefits, including sickness benefit/pay, n (%)	442 (66)
Previous low back operation, n (%)	139 (20)
Days of hospital stay, mean (SD)	3 (3)
BMI, mean (SD)	27 (5)
ODI, mean (SD)	46 (18)
NRS back pain, mean (SD)	6 (3)
NRS leg pain, mean (SD)	7 (2)
EQ-5D, mean (SD)	0.26 (0.35)

BMI: body mass index.

misclassification. We also computed the area under the curve (AUC), which reflects the accuracy of the instruments to differentiate between success and no success. An AUC value of > 0.70 was considered satisfactory (de Vet et al. 2007).

We carried out sensitivity analyses for cutoff values in the following subgroups: patients operated with microsurgical technique, patients operated with open discectomy, patients operated for the first time, and those who had been operated previously.

Floor and ceiling effects

We assessed floor and ceiling effects by calculating the frequency of the highest possible scores and the lowest possible scores at baseline. Floor effects were considered to be present if more than 15% of the patients had a minimal score at baseline (0 on the scales). Ceiling effects were considered to be present if more than 15% of the patients had a maximum baseline score (10 on the pain scales and 100 on the ODI) (de Vet et al. 2007).

Results

Of 894 patients registered with an operation for disc herniation, 202 (23%) did not return the postal questionnaire at 1 year, and they were excluded. Our study therefore included 692 patients (Table 1). Mean age was 46 (SD 13) years and 408 (59%) of the patients were males.

Of the 692 patients included at baseline, 688 had complete 1-year follow-up data on all outcome measures and the global perceived change scale. At 1 year, there were few missing data on ODI (1 patient), back pain (0 patients), and leg pain (5 patients), whereas 35 patients lacked 1-year scores for the EQ-5D. All patients were operated at 1 level (n = 660) or at 2 or more levels (n = 32) between L2 and S1; 557 (80%) were operated with the use of microscope or loupes and 135 (20%) were operated without any visual enhancement ("open discectomy"). In 13 cases (2%), a laminectomy was performed. The rest were operated with less invasive procedures. None had additional fusion surgery or total disc replacement. 539 patients (80%) were operated for the first time, and 139 (20%) had been operated previously at the same level (13%) and/or a different level (8%). The complication rate was 60/692 (4%), including 19 wound infections, 9 dural tears, 7 nerve root injuries, 17 hematomas, and 8 other minor complications.

The Spearman rank correlation coefficients between the global scale and the change scores of the instruments were 0.61 (ODI), 0.57 (back pain), 0.60 (leg pain), and 0.55 (EQ-5D) (Table 2).

Cutoff values for success

The ROC curve analyses (Figure) showed an AUC (95% CI) for the ODI of 0.85 (0.83–0.89), NRS back 0.82 (0.78–0.85), NRS leg 0.84 (0.81–0.88), and EQ-5D 0.80 (0.76–0.84). The cutoff value (sensitivity, specificity) to distinguish between success or lack of success was a change score of 20 (0.78, 0.77) for the ODI, 2.5 (0.74, 0.77) for back pain, 3.5 (0.81. 0.73) for leg pain, and 0.3 (0.74, 0.68) for the EQ-5D. The

Table 2. The mean change scores (95% CI) of the 4 instruments according to the global perceived change scale (anchor) at 1 year

Global scale (categories)	n (%)	ODI Mean change [a]	NRS back pain Mean change [a]	NRS leg pain Mean change [a]	EQ-5D Mean change [a]
Completely recovered (1)	167 (24)	43 (42–45)	6 (5–6)	7 (6–7)	0.7 (0.7–0.7)
Much improved (2)	318 (46)	32 (31–33)	4 (4–4)	5 (5–5)	0.5 (0.5–0.5)
Slightly improved (3)	118 (17)	15 (13–17)	1 (1–2)	3 (3–4)	0.3 (0.3–0.3)
No change (4)	47 (7)	8 (5–10)	0 (0–0)	1 (0–1)	0 (0–0.1)
Slightly worsened (5)	15 (2)	0 (–5 to 5)	–1 (–1 to 0)	–1 (–2 to 0)	–0.1 (–0.2 to 0)
Much worsened (6)	18 (3)	–4 (–8 to 1)	–2 (–2 to –1)	0 (–1 to 1)	–0.1 (–0.2 to 0)
Worse than ever (7)	5 (1)	–21 (–30 to –13)	–2 (–4 to –1)	–1 (–3 to 1)	–0.4 (–0.5 to –0.2)
Total [b]	688	28 (27–29)	3 (3–3)	5 (4–5)	0.5 (0.5–0.5)

[a] ANCOVA with adjustment for baseline scores.
[b] Patients with complete data on all outcome measures.

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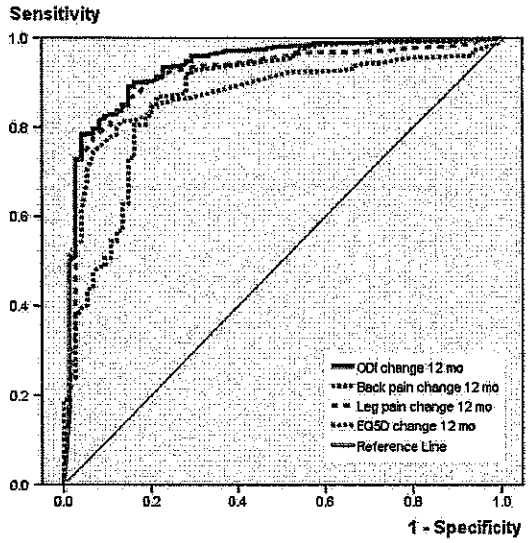

ROC curves for Oswestry disability index (ODI), back and leg pain scores, and EuroQol (EQ-5D).

Table 3. The mean change scores (95% CI) according to the cutoffs for success for each of the 4 instruments . Values are mean change (95% confidence interval) [a]

	ODI	NRS back pain	NRS leg pain	EQ-5D
Success	37 (36–39)	5 (5–5)	6 (6–6)	0.7 (0.6–0.7)
No success	10 (9–12)	1 (0–1)	1 (1–2)	0.1 (0.1–0.2)

[a] ANCOVA with adjustment for baseline scores; n = 688.

sensitivity and specificity values were highest for ODI and the leg pain scale and they were lowest for the EQ-5D. Table 3 shows the mean change scores when using these cutoff values for success for each of the 4 instruments. According to the criteria, the proportion of patients with success at 1-year follow-up was 66% for the ODI, 67% for leg pain, 59% for back pain, and 61% for EQ-5D.

Sensitivity analyses

When we compared (1) the patients who were operated with microsurgical technique with those operated with open discectomy, and (2) the patients who were operated for the first time with those who had been operated previously, we found approximately the same the cutoff values and sensitivity/specificity values (Table 4). The success criteria in the subgroup of patients who had been operated previously had to be slightly higher for the ODI and NRS leg pain in order to reach the precision of the cutoff values observed in the total study population.

Floor and ceiling effects

There were no floor and ceiling effects in the 4 instruments. Only 8 patients scored 0 in the ODI, and 1 patient scored 100 at baseline. None of the patients scored 0 in the NRS pain scales, but 10 patients had the maximum score of 10 at baseline. This was still below the level of 15%, which is the criterion for definition of floor/ceiling effects. In the EQ-5D, only 1 patient had the maximum score of 1 at baseline, reflecting optimal health.

Discussion

In this study, we estimated cutoff values to identify patients with successful outcomes after surgery for lumbar disc herniation according to 4 commonly used patient-reported outcome instruments: the ODI, the NRS back and leg pain scales, and the EQ-5D. ODI and NRS leg pain were best for discrimination between a successful outcome and an unsuccessful outcome. The cutoff value was 20 for ODI and 3.5 for NRS leg

Table 4. Sensitivity analysis of area under the curve (AUC) with 95% CI and sensitivity/specificity (sens, spec) of cutoff values across 4 subgroups

	All (n = 692)		Operated with microsurgical technique (n = 557)		Operated with open discectomy (n = 135)		Operated for the first time (n = 539)		Previously operated (n = 139)	
	AUC (95%CI)	Cutoff (sens, spec)	AUC (95%CI)	Cutoff (sens, spec)	AUC (95%CI)	Cutoff (sens, spec)	AUC (95%CI)	Cutoff (sens, spec)	AUC (95%CI)	Cutoff (sens, spec)
ODI	0.85 (0.83–0.89)	20 (0.78, 0.77)	0.86 (0.83–0.90)	20 (0.79, 0.77)	0.84 (0.77–0.92)	20 (0.77, 0.74)	0.87 (0.84–0.91)	20 (0.76, 0.80)	0.83 (0.75–0.90)	20 (0.83, 0.67)
NRS back pain	0.82 (0.78–0.85)	2.5 (0.74, 0.77)	0.83 (0.79–0.86)	2.5 (0.74, 0.76)	0.79 (0.70–0.88)	2.5 (0.73, 0.81)	0.83 (0.79–0.87)	2.5 (0.73, 0.81)	0.80 (0.72–0.88)	2.5 (0.80, 0.67)
NRS leg pain	0.84 (0.81–0.88)	3.5 (0.81 0.73)	0.84 (0.80–0.88)	3.5 (0.81, 0.72)	0.85 (0.77–0.92)	3.5 (0.81 0.73)	0.87 (0.83–0.90)	3.5 (0.81 0.67)	0.78 (0.69–0.87)	3.5 (0.83, 0.64)
EQ-5D	0.80 (0.76–0.84)	0.3 (0.74, 0.68)	0.80 (0.75–0.84)	0.3 (0.75, 0.67)	0.79 (0.71–0.87)	0.3 (0.67, 0.73)	0.82 (0.78–0.86)	0.3 (0.74, 0.72)	0.72 (0.63–0.81)	0.3 (0.72, 0.53)

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pain. According to the ROC analysis, the EQ-5D had the poorest sensitivity and specificity values.

We defined patients who reported that they were "completely recovered" or "much better" to have had a successful outcome or a substantial amount of improvement. We used strict criteria—"completely recovered" or "much better"—as a cutoff (anchor) for a successful outcome. Consequently, the current cutoff values were higher than what has been reported for MCID previously (Copay et al. 2008). We argue that as long as we do not have better external criteria to distinguish between improved and unimproved patients, we consider that it is scientifically sound to provide the least biased estimates for success after surgery. However, we are aware that there will be patients with a possibly successful outcome among those classified as having an unsuccessful one (false negatives).

Although the AUCs were acceptable for all the instruments (> 0.70), ODI and NRS leg pain showed better ability to discriminate between success and lack of success for patients who have undergone back surgery than the 2 other outcome measures. Glassman et al. (2008) used substantial clinical benefit thresholds similar to ours for the ODI and the pain scales in patients who were operated with lumbar spine arthrodesis. They found a cutoff for success of 19 ODI points, which is very similar to our results. However, they used the SF-36 health transition item as another external anchor, whereas we used the global perceived change scale. Copay et al. (2008) reported lower estimates of 13 points for the ODI, 1.2 points for NRS back pain scale, and 1.6 points for NRS leg pain scale. However, they used a mixed patient sample involving different lumbar spine surgery procedures, and they used cutoff values similar to the MCID (and not related to a substantial improvement).

A weakness of the present study was that the loss to follow-up was relatively high (22.6%). However, the aim of the study was to define cutoffs over a range of outcomes, and not to evaluate the effectiveness of the surgical treatment. In a recent study on an equivalent patient population with 22% non-respondents, we found no difference in outcomes between responding and non-responding cohort participants at long-term follow-up (Solberg et al. 2011). Thus, we do not expect that loss to follow-up would bias our effects-size assessments.

Another weakness was the use of the global change scale as an external anchor. Kemper et al. (2010) showed that global change scale ratings are strongly influenced by the current health status of the patient and that they may not offer an accurate measure of change as transition time increases. This is a challenge for all clinimetric studies, since at the moment there are no alternative external anchors for self-reported questionnaires.

The study had several advantages. We used a theoretically sound method by using a concept of success that reflected a substantial amount of change. Such benchmark criteria would be valuable for clinical spine surgery registries in monitoring effectiveness of treatment and comparing treatment outcomes between surgical units and over time. Finally, all the cutoff estimates, reflecting a substantial amount of change, were considerably larger than previously reported estimates of measurement error or minimal detectable change (Grotle et al. 2004).

In summary, the ODI and the NRS leg pain scale showed the best ability to discriminate between success or lack of success in patients who had been operated for lumbar disc herniation. We recommend that a change score of at least 20 points in the ODI and of at least 3.5 in NRS leg pain should be achieved to ensure a successful outcome or substantial change after surgery. These cutoffs for success can enhance interpretation of outcomes in different surgical units.

TKS: idea, protocol, data collection, data analysis, and writing. LGJ: protocol, data analysis, and writing. ØPN: data collection, data analysis, and writing. MG: idea, protocol, data analysis, and writing.

No competing interests declared.

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Prospective multiple outcomes study of outpatient lumbar microdiscectomy: should 75 to 80% success rates be the norm?

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Abstract

Object: The authors assessed the efficacy and outcomes of lumbar microdiscectomy performed on an outpatient basis by administering six questionnaires before and at five time points after surgery. The results were compared with those reported in literature in which the success rates vary between 70% and 80% and in excess of 90%. The authors use the methodology and data derived from their study to evaluate critically the relevance of these two categories of success rates.

Methods: This is a prospective study of 212 consecutive, eligible patients who underwent outpatient microscopic discectomy for the treatment of lumbar disc herniation: no previous lumbar lesion had been treated. Data were collected from questionnaires given to the patients before and at five time points after surgery, including at a variable final follow-up examination (mean 2 years postoperatively). Data were collated and analyzed independently by individuals other than the operating surgeons. In both bi- and multivariate analyses, only two preoperative parameters were prognostically significant. The first factor was Workers' Compensation status, which had a negative effect on outcome. The second factor was patient age, which also had a negative effect and was linear with increasing age between 25 years and 56 years--that is, the ages most commonly encountered in cases of herniated disc. Successful outcome rates were as follows: leg pain relief according to a visual analog scale (VAS), 80%; back pain relief (VAS), 77%; Oswestry Low Back Disability Index, 78%; satisfaction with the results of surgery, 76%; return to normal daily activities, 65%; and return to work, 61%.

Conclusions: The findings of this study support the evidence that lumbar microdiscectomy performed on an outpatient basis is a very safe and effective means of treating sciatic pain due to disc herniation. The authors believe that their outcome success rates of 75 to 80% are more realistic than those of 90% or more found in some reports.

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ORIGINAL ARTICLE

Risk factors for poor outcome of surgery for cervical spondylotic myelopathy

JT Zhang, LF Wang, S Wang, J Li and Y Shen

Study design: Prospective study.
Objectives: The purpose of this study was to characterise risk factors for poor surgical outcome in patients with cervical spondylotic myelopathy (CSM).
Methods: The prospective study included 110 consecutive patients who underwent surgical treatment for CSM. Surgical outcomes were evaluated according to the Japanese Orthopaedic Association (JOA) score. JOA recovery rate <50% was defined as poor surgical outcome. Relationship between outcome and various clinical and imaging predictors was examined. By multivariate logistic regression analysis, we identified risk factors associated with poor outcome. Receiver operating characteristic curves were plotted to acquire cutoff values for the continuous variables found to be independently associated with poor outcome.
Results: Forty-two patients (38.2%) had a recovery rate of <50%. Logistic regression, with poor outcome as dependent variable, showed independent risks associated with increased age (odds ratio (ORs)=1.08, 95% confidence interval (CI)=1.01–1.15, P=0.021), symptom duration (OR=4.01, 95% CI=1.95–8.23, P=0.000) and signal intensity ratio (SIR, OR=4.24, 95% CI=1.61–11.20, P=0.003). The cutoffs with the best compromise between sensitivity and specificity were set at 63.1 years of age, 9 months of symptom duration and 1.455 for SIR. The presence of ⩾2 out of three factors (age ⩾63.1 years, symptom duration ⩾9 months and SIR ⩾1.455) gave an overall OR of 33.15 (95% CI=4.11–267.37, P=0.001).
Conclusion: These findings suggest that advanced age, long-term CSM symptoms and high preoperative SIR are risk factors for poor outcome of surgery in patients with CSM.
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INTRODUCTION

Cervical spondylotic myelopathy (CSM) is a common cause of spinal cord dysfunction that generally requires surgical treatment owing to its progressive nature.[1] The optimal treatment strategy of CSM is dependent on both progression and stage of disease. However, controversy remains regarding conservative versus surgical management, as favourable results have been reported for both.[2] Patients with CSM have various symptoms such as sensory abnormality of the trunk or extremities, gait disturbance and urinary dysfunction.[1,3] Although decompressive surgery is an available treatment option for this disease, the surgical outcome is not always satisfactory. Prognostic guidelines are still unclear, and it is very difficult for the surgeon to predict postoperative recovery.

Magnetic resonance imaging (MRI) is a valuable tool before surgical decompression because it allows the visualisation not only of the magnitude of spinal cord compression but also of intramedullary signal intensity. The presence of intramedullary increased signal intensity (ISI) on T2-weighted imaging (WI) in patients with CSM reflects chronic spinal cord compression.[4–6] However, controversy exists in the reported results, mainly because of the lack of a proper quantitative assessment method of signal intensity changes in spinal cord.[4,5,7–16] Wang *et al.*[17] first used signal intensity ratio (SIR) as a quantifiable measure of signal intensity in cervical compressive myelopathy. Therefore, we hypothesised that there was a relationship between neurological function recovery after surgery and quantitative signal intensity on MRI. In addition to examining this relationship, we also designed the current study to identify risk factors associated with poor outcome, particularly the predictive value of quantitative SIR, after surgical treatment for CSM and provide insight into how surgeons undertake decision-making.

MATERIALS AND METHODS

Ethics statement

The study was approved by Ethics Committee of the Third Hospital of Hebei Medical University in China. All participants gave their informed consent to assessing and using their data. The methods were carried out in accordance with the approved guidelines.

Patient population

From January 2010 to December 2012, 266 patients with clinically diagnosed and imaging-confirmed CSM underwent surgical treatment at the Department of Spinal Surgery, the Third Hospital of Hebei Medical University in China. Operative indications for CSM patients were as follows: (1) up to three levels of anterior cord compression: anterior surgery; (2) more than three levels of anterior cord compression: posterior surgery; and (3) anterior and posterior cord compression: posterior with or without anterior surgery. Exclusion criteria were previous cervical spine surgery, vitamin B deficiency, rheumatoid arthritis,

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cervical ossification of the posterior longitudinal ligament, and concomitant lumbar spinal stenosis or other neurological disorders before their CSM surgery or during follow-up. A total of 110 patients with CSM who were followed for 12 months or more after surgery were prospectively enroled in this study. There were 63 men and 47 women, ranging in age from 38 to 81 years, with a mean age of 64.7 years. CSM was defined as a constellation of symptoms and signs supported by appropriate imaging studies, including routine radiographs, computed tomography and MRI.

All enroled patients underwent surgical decompression combined with instrumented fusion. Patients treated anteriorly underwent cervical discectomy and fusion, or cervical corpectomy and fusion. Posterior procedures included laminoplasty, or laminectomy and fusion. The surgical approach (anterior, posterior or a combination) and the number of operated segments were determined by one surgeon (YS). Data at the 12-month follow-up visit were used to assess important predictors of outcome, as 12 months represent a typical time period of optimum recovery after operation for CSM.

Neurological assessment

The preoperative and postoperative neurological function at 12 months of follow-up was assessed using the Japanese Orthopaedic Association (JOA) scoring system (Table 1). Postoperative improvement of symptoms was estimated on the basis of the recovery rate= (postoperative JOA score−preoperative JOA score)/(17−preoperative JOA score)×100%. A score of 75–100% was designated as excellent, 50–74% as good, 25–49% as fair and 0–24% as poor. Therefore, in this study, we defined a poor surgical outcome as a recovery rate <50%.

Radiographic assessment

Spinal alignment was measured on cervical spine radiographs. The C2-7 angle was measured between the posterior border of the C2 vertebral body and posterior border of the C7 vertebral body on lateral radiographs with patients in a neutral position. The Cobb method was used to measure the C2-7 range of motion through the change in the maximal flexion and extension by lateral radiographs.

All patients underwent preoperative high-resolution MRI with a 1.5-T system (Magnetom Symphony, Siemens Medical Solutions, Malvern, PA, USA). The MRIs of the spinal cord were obtained using a spin echo sequence system for T1-WI and a fast spin echo sequence system for T2-WI. The ISI values of the spinal cord on sagittal T2-WIs were obtained, and the regions of interest were taken by 0.05 cm^2. The normal spinal cord signal intensity values on sagittal T2-WIs were obtained at the C7-T1 disc level, and the regions of interests were taken by 0.3 cm^2. If no intramedullary ISI was noted on T2-WIs, the regions of interests were taken by 0.05 cm^2 of the severely compressed cord. The SIR was defined as the signal intensity at the level of ISI or severely compressed cord (in cases with no ISI) divided by the signal intensity at the C7-T1 disc level. The signal intensity value was measured on the MRI workstation, and the SIR was calculated. The selection of the regions of interests was based on the balance of a number of factors. For instance, an extremely large area would not hold all patients in the group, whereas an extremely small area would jeopardise the accuracy of the signal intensity value.

Table 1 Comparison of patient characteristics between good and poor recovery groups

Variable	*Good (n = 68)*	*Poor (n = 42)*	*P-value*
Age at operation (years)	62.4±9.1	68.5±8.2	0.001
Female sex (*n*, %)	29 (42.6%)	18 (43.0%)	0.983
BMI (kg m^{-2})	25.7±3.1	25.1±4.3	0.385
Diabetes mellitus (*n*, %)	19 (28.0%)	8 (19.0%)	0.292
Duration of symptoms (months)	10.1±7.5	20.7±15.6	<0.001
Preoperative JOA score	10.2±2.6	9.6±2.2	0.195
JOA score at 12-month follow-up	14.7±1.0	11.8±2.3	<0.001
Recovery rate (%)	66.9±10.4	32.3±11.7	<0.001
SIR	1.29±0.17	1.65±0.37	<0.001
C2-7 angle (deg.)	16.3±5.6	15.6±6.3	0.597
C2-7 ROM (deg.)	16.9±9.9	17.3±6.1	0.812
Levels involved	2.1±1.0	2.0±1.1	0.588
Surgical approach			
Anterior	41	31	0.334
Posterior	21	8	
Combined anterior/posterior	6	3	

Abbreviations: BMI, body mass index; JOA, Japanese Orthopaedic Association; SIR, signal intensity ratio; ROM, range of motion.

Statistical analysis

Descriptive analysis of the patient population was conducted using means and standard deviations for continuous variables and frequencies and percentages for categorical variables. The duration of symptoms was estimated as the period from the onset of the primary neurological symptom to the time of surgery. Univariate analyses were performed to identify correlations between surgical outcome at 12 months of follow-up and prognostic factors. Comparison of continuous variables among the different groups was made using Student's *t*-test or the Mann–Whitney *U*-test, as appropriate. The categorical variables were compared by the χ^2 test. Multivariate logistic regression analysis was also performed to control for potential confounding variables with the dependent variable of 'poor outcome'. Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were presented with their respective *P*-values. Factors with a *P*-value <0.05 in univariate analysis were entered into the multivariate logistic model. The receiver operating characteristic curve analysis was constructed to evaluate the cutoff values for the continuous variables found to be independently associated with poor outcome. Finally, the logistic regression analysis was again used to test the association between poor outcome and the combination of variables with the best diagnostic accuracy for predicting poor outcome after adjusting for possible confounding factors. A value of $P<0.05$ was considered to represent a statistically significant difference. All analyses were performed using SPSS software (version 21.0; SPSS Inc., Chicago, IL, USA).

RESULTS

The range of SIR was 1.08–2.86 for all patients. Figure 1 illustrated the measurement of SIR on the MRI workstation. For all patients, the mean JOA score was 9.9 points preoperatively, and 13.6 points at 12 months postoperatively, yielding a mean recovery rate of 53.6%. Thus, a statistically significant improvement in the JOA score was obtained at the 12-month follow-up ($P<0.001$). Sixty-eight patients had good surgical outcomes, with recovery rates ⩾50%, whereas 42 patients had poor surgical outcomes with recovery rates <50%. Compared with the good-outcome group, the poor-outcome group had a significantly higher mean patient age ($P=0.001$) and preoperative SIR on T2-WI ($P<0.001$) and a significantly longer symptom duration ($P<0.001$, Table 1). In multivariate logistic regression analysis, age (OR=1.08, 95% CI=1.01–1.15, $P=0.020$), symptom duration (OR=4.01, 95% CI=1.95–8.23, $P=0.000$) and SIR (OR=4.24, 95% CI=1.61–11.20, $P=0.003$) were independently associated with poor outcome (Table 2).

The receiver operating characteristic curve analysis showed that age, symptom duration and preoperative SIR, taken singly, had a good accuracy for predicting poor outcome (area under the curve: 0.702, 0.820 and 0.829, respectively; $P=0.000$, $P=0.000$, $P=0.001$, respectively). The cutoffs with the best compromise between sensitivity and specificity were set at 63.1 years of age, 9 months of symptom duration and 1.455 for preoperative SIR (Figure 2 and Table 3). The presence of ⩾2 out of three factors (age ⩾63.1 years, symptom duration ⩾9 months and serum creatinine ⩾1.455) was significantly associated with poor surgical outcome (OR=33.15, 95% CI=4.11–267.37, $P=0.001$; Table 4).

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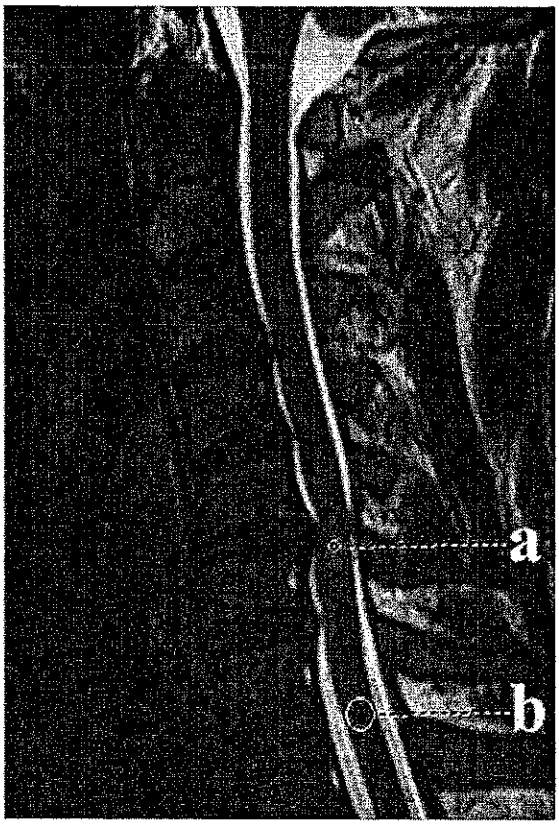

Figure 1 Measurement of SIR on MRI. SIR was defined as the signal intensity of (a and b).

Table 2 Risk factors for poor outcome after operation: multiple logistic regression analysis

Variable[a]	*OR (95% CI)*	P-*value*
Age at operation (1-year increase)	1.08 (1.01–1.15)	0.020
Duration of symptoms (months)	4.01 (1.95–8.23)	0.000
SIR	4.24 (1.61–11.20)	0.003

Abbreviations: CI, confidence interval; OR, odds ratio; SIR, signal intensity ratio.
[a]Duration of symptoms: 1. ⩽3 months; 2. >3 but ⩽6 months; 3. >6 but ⩽12 months; 4. ⩾12 but ⩽24 months; 5. >24 months. SIR: 1. ⩾1.00 but ⩽1.50; 2. >1.50 but ⩽2.00; 3. >2.00 but ⩽2.50; 4. > 2.50.

DISCUSSION

Recognition of the best timing for surgery to ensure neurological improvement is an important clinical issue. Previous studies have shown that numerous factors affect postoperative outcomes of patients with CSM, including age,[18] duration of CSM symptoms,[7,10,18–21] signal changes on preoperative MRI[5,6,11,13,22] and preoperative JOA score.[23–25] However, the list of predictive factors differs according to researchers, and the prognostic significance of these factors remains controversial. In our study, we used a logistic regression model to determine the risk factors related to having a poor postoperative outcome. We demonstrated that patients with poor surgical outcome tended to have older age, longer duration of CSM symptoms and higher preoperative SIR than those patients with good outcome.

Previous studies have suggested that the spinal cord is vulnerable to the degeneration of motor neurons and myelinated fibres in elderly patients.[26,27] The results of the univariate analysis showed that patients in the poor-outcome group were significantly older than those in the good-outcome group ($P=0.001$). Multivariate logistic analysis demonstrated that age was a predictor, and the odds of a poor outcome were 1.08 times greater for every 1-year increase in the patient age. This may be explained that the elderly experience age-related changes in the spinal cord including a decrease in the number of γ-motoneurons, number of anterior horn cells and number of myelinated fibres in the corticospinal tracts and posterior funiculus. In addition, general degeneration associated with the normal ageing process and increased risk of underlying diseases also have negative influence on surgical outcome. Although most surgeons will not discriminate on the basis of age, they should be aware that elderly patients may experience poor neurological recovery.

The duration of symptoms affects the severity and progression of the disease due to chronic compression by the lesions. Patients with poor surgical outcome for CSM were observed to have a longer duration of symptoms in the present study. The rationale is that

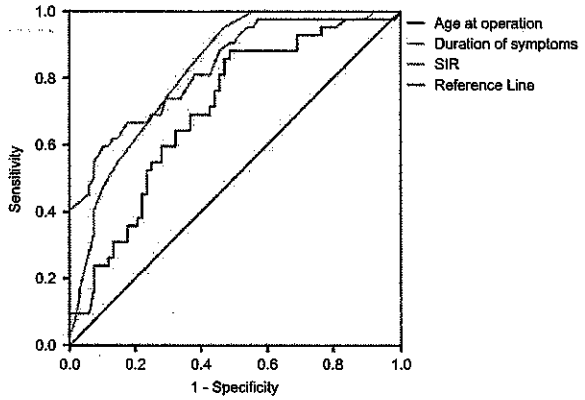

Figure 2 In receiver operating characteristic curves, the optimal cutoff values of age, duration of symptoms and SIR are shown for prediction of a poor surgical outcome.

Table 3 Sensitivity, specificity, AUC and cutoff of risk factors for predicting poor outcome

Variable	*SN*	*SP*	*AUC*	*Cutoff*	*P-value*
Age at operation (years)	0.857	0.529	0.702	63.1	0.000
Duration of symptoms (months)	0.925	0.529	0.820	9	0.000
SIR	0.667	0.824	0.829	1.455	0.001

Abbreviations: AUC, area under the curve; SN, sensitivity; SP, specificity; SIR, signal intensity ratio.

Table 4 Differences in the incidence of poor outcome after operation in patients with 0, 1 or ⩾2 factors

Factor	*OR (95% CI)*	*P-value*
0 factor	1	
1 factor	1.10 (0.09–12.99)	0.942
⩾2 factors	33.15 (4.11–267.37)	0.001

Abbreviations: CI, confidence interval; OR, odds ratio.

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chronic and long-standing compression of the spinal cord may lead to irreversible damage due to demyelination and necrosis of the grey matter. The longer the spinal cord is compressed by the lesions, the greater possibility of irreversible injury might exist. Therefore, to achieve the best results, surgical intervention should be undertaken as early as possible.

The utility of spinal cord MRI signal intensity has been widely studied, and various authors have speculated on its histopathologic significance and impact on surgical outcome. It has been reported that oedema, myelomalacia and gliosis involve ISI on T2-WI, suggesting irreversible changes of the spinal cord, and this signal intensity change was significantly associated with poor postoperative outcome of CSM.[4,5,10–12] Intramedullary signal change on MRI is generally considered to reflect nerve tissue degeneration. These findings may range in severity from reversible cord oedema and ischaemia to irreversible cavitation and necrosis. Despite such evidence, many studies found no correlation between surgical outcome and intramedullary ISI on T2-WI.[7,13–16,28,29] In the present study, SIR was the quantitative method used to assess the changes of signal intensity, as described in the previous study.[17] The ISI on T2-WI is irregular in each scan, even when using the same MRI system, because the different sequence parameters are selected individually for each patient. Therefore, ISI on T2-WI is a wide-ranging variant that usually encompasses many levels of actual severity. Application of quantitative analysis can avoid possible judgment errors by each investigator. In the present study, high preoperative SIR can predict poor outcome after surgical treatment for patients with CSM. Specifically, the odds of a poor postoperative outcome were 4.24 times greater for every half-point increase in the preoperative SIR. We calculated that the optimal cutoff value of preoperative SIR as a predictor of poor postoperative outcome was 1.455.

In the present study, sex, body mass index, diabetes mellitus and preoperative JOA score did not influence the outcome of the surgical intervention. The C2-7 angle, C2-7 ROM, the number of involved segments and surgical approach did not correlate with poor postoperative outcome. It is also uncertain whether these factors are predictive of surgical outcome, as our findings may be inconsistent with the results of previous studies. It remains to be seen, however, whether these factors are truly unrelated to surgical outcome. It is possible that statistical significance was not reached in this study because of the different statistical tests used across the different studies.

In the present study, the cutoffs used for age, symptom duration and preoperative SIR were assessed by receiver operating characteristic curve analysis. Another finding of interest is that patients with at least two out of three above-mentioned factors (age, symptom duration and preoperative SIR) were associated with 33.15-fold higher risk for poor surgical outcome compared with patients without risk factors. Whether this may be a useful clinical tool for indentifying CSM patients at risk for poor postoperative outcome deserves further study.

There are several limitations that need to be considered in our study. First, this was a single-centre study and involved only a limited number of CSM patients. Second, our follow-up term was 12 months after surgery, indicating that the relationship between the predictive factors and long-term outcome of neurological function could not be clearly established, although we could broadly predict the future condition from the trends observed. Third, although the JOA score is generally utilised, patient-reported outcomes were not considered in the study. Four, each high-resolution MRI system has different characteristic and working parameters, which may explain the differences between our results and those of previous studies. Therefore, these limitations suggest that our findings require further validation of these results in larger patient samples.

CONCLUSIONS

The quantification of signal intensity on MRI for patients with CSM was used in the present study to assess the impact of intramedullary signal change on the surgical outcome. Advanced age, long-term CSM symptoms and high preoperative SIR are risk factors for poor outcome of surgery in patients with CSM. As persistent cord compression and disease progress may lead to a treatment failure, an understanding about the importance of predictive factors can help surgeons consider the indications of surgical treatment and evaluate the timing of surgery.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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DATA ARCHIVING

There were no data to deposit.

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THE STATE OF SOUTH CAROLINA
In The Court of Appeals

APPEAL FROM THE
SOUTH CAROLINA WORKER'S COMPENSATION COMMISSION

Gene McCaskill, Commissioner
R. Michael Campbell, II, Commissioner
T. Scott Beck, Commissioner

SCWCC File No. 1508995

Appellate Case No. 2018-001964

Samuel Paulino, Claimant — Respondent,

v.

Diversified Coatings, Inc., Employer, and AmGuard Ins. Co., Carrier — Appellant.

PROOF OF SERVICE

I certify that I have served the Petition for Rehearing on Diversified Coatings, Inc., by email at ggallagher@speed-seta.com to their attorney of record, George D. Gallagher, Esq.

March 22, 2022

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