Influence of lumbar stenosis surgery on sacroiliac joint pain—Long-term results

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OBJECTIVE: **To investigate whether sacroiliac join (SIJ) pain can be secondary to walking with a flexed posture resulting from stenosis with neurogenic claudication, and resolves spontaneously after lumbar decompression.**

METHODS: **A review of charts from January 1, 2014, through March 3, 2019, was performed to identify consecutive cases of adults 35 years of age or older with surgical spinal stenosis with neurogenic claudication as well as concomitant severe SIJ pain. Posture was considered flexed during walking if self-reported, confirmed by a close companion, or observed directly. SIJ pain was diagnosed clinically ± confirmatory injection. A 10-point visual analog scale was used to assess SIJ pain. The primary endpoint was SIJ pain improvement at a minimum of 24 months' follow-up. SIJ pain improvement at 3 months was used to assess the rate of improvement as a secondary endpoint.**

RESULTS: **Ten patients (3 female) met entry criteria: 4 were treated with decompression alone; 6 with decompression and spinal fusion. Mean SIJ visual analog scale pain score improved by 6.9 ± 2.4 (8.7 ± 1.6—1.8 ± 2.2; $P < 0.0005$). Results were similar for 20 patients at the secondary endpoint of 3 months.**

CONCLUSIONS: **Sacroiliac joint pain shows robust, rapid, reliable, and durable improvement following lumbar decompressive surgery. The addition of a spinal fusion also leads to a similar improvement in SIJ pain. This study demonstrates the importance of evaluating the specific source of low back pain in patients with stenosis, claudication, and SIJ pain so as to more effectively plan appropriate surgery.**

INTRODUCTION

Many patients have both claudication symptoms resulting from lumbar stenosis as well as concomitant sacroiliac joint (SIJ) pain. Lumbar laminectomy for the treatment of lumbar stenosis with neurogenic claudication is well documented in the literature.[1-6] Similarly, evidence exists that low back pain patients with stenosis demonstrate clinically significant improvement in their low back pain with laminectomy alone.[7] However, previous studies did not discriminate between low back pain that was of myofascial, discogenic, facet, or SIJ origins.

Patients suffering from spinal stenosis with neurogenic claudication typically adopt a flexed posture during ambulation.[8] Claudication is typically worse walking and better walking in a flexed position. This posture increases the lumen diameter of the spinal canal, alleviating their leg pain.

Many patients have both claudication symptoms resulting from lumbar stenosis as well as concomitant SIJ pain that starts at the same time or after the onset of claudication symptoms. We hypothesize that this SIJ pain is secondary to walking with a flexed posture to alleviate claudication symptoms. Here, we evaluate if this "secondary SIJ pain" will spontaneously improve after lumbar laminectomy or laminectomy with spinal (without SIJ) fusion when patients resume walking upright. Furthermore, scoliosis films taken at a single instant in time when patients are consciously standing upright in a stationary position may not accurately reflect the extent to which patients adopt a flexed

Key words
- Laminectomy
- Low back pain
- Lumbar fusion
- Lumbar stenosis
- Neurogenic claudication
- Sacroiliac joint
- Sacroiliac joint pain

Abbreviations and Acronyms
CT: Computed tomography
SIJ: Sacroiliac joint
VAS: Visual analog scale

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posture when ambulating. We therefore hypothesize that scoliosis films in patients with stenosis-induced claudication and flexed posture when ambulating will neither accurately depict the extent of flexed posture when walking, nor correlate with the presence of secondary SIJ pain.

METHODS

After approval was obtained from the University of South Florida institutional review board, a retrospective review of charts from January 1, 2014 through the March 3, 2019 was performed to identify consecutive cases of adults 35 years of age or older with concomitant surgical spinal stenosis, neurogenic claudication including a history of walking with flexed posture, as well as severe SIJ pain. Posture was considered flexed during walking if self-reported, confirmed by a close companion, or observed directly. Patients were included if SIJ pain began at the same time or after the onset of claudication symptoms. Patients with pre-existing SIJ pain were excluded, as were patients with the onset of SIJ pain with trauma to the SIJ. Pain in the region of the SIJ was rated using a 10-point visual analog scale (VAS) score, and only those with severe SIJ pain (>5) were included.

SIJ pain was diagnosed clinically if patients had all of the following:

Pain in the SIJ Region

- Severe pain (VAS >5) in the SIJ region and below the L5 level
- Sitting intolerance
- A positive Fortin finger test
- ≥ 3 positive stress tests of the SIJ (thigh thrust; flexion, abduction, and external rotation; Gaenslen's; pelvic distraction; lateral compression)[9,10]
- 3 complaints typically observed with SIJ pain: sitting asymmetry (shifting from side to side, sitting with 1 buttock elevated, an arm extended to unweight the SIJ or with the ipsilateral leg extended or crossed); SIJ pain exacerbation when: sitting on the ipsilateral buttock, transitioning from sitting to standing, walking up a stair with the ipsilateral leg, walking up an incline, standing on the ipsilateral leg, the heel hits the ground walking, laying on the ipsilateral side, or rolling over in bed. SIJ pain may improve in a recliner. There may be sudden ipsilateral leg give-way (with or without falling), referred pain[11] to the inguinal region, anterior or lateral thigh or the L5 or S1 distribution—and if present, worse referred pain with sitting and improvement in a recliner. These symptoms are often also seen with piriformis muscle syndrome, but the physical exam findings help distinguish between these two entities.
- Other physical examination findings of SIJ pain that are typically positive that further strengthen the diagnosis include: point tenderness over the posterior sacroiliac ligament; a positive Patrick's test, line drawing typical of SIJ pain with or without referred pain, step-up test, stork test, and pain in the SIJ with pressure on the SIJ using the fist with ipsilateral thigh immobilization. Referred pain must occur in the absence of motor, sensory, or reflex changes on physical examination, and may be elicited by sitting on the ipsilateral buttock while in the clinic (personal observation). Of note, many patients in this study had radicular leg pain worse with walking, and better walking flexed due to the stenosis, in addition to SIJ-induced pseudo-radicular leg pain made worse by sitting and improved in a recliner. Also, with SIJ pain, there may be no obvious cause of the low back pain on magnetic resonance imaging or x-rays.
- Referred inguinal pain from the SIJ must be differentiated from referred inguinal pain from the hip on physical examination. If referred pain to the inguinal area, anterior or lateral thigh, or the L5/S1 distribution is present, this also may worsen with the Gaenslen's test (but not the straight leg raise test) in addition to the SIJ pain.
- SIJ pain can be differentiated from facet pain at L5/S1, which is at the belt line (not below), is located closer to the midline, typically is worse with hyperextension and lateral bending, and can usually be detected on a single photon emission computed tomography (CT)-CT scan. Furthermore, axial low back pain derived from the disc or facet is usually worse standing up (with gravity loading) and better laying down. SIJ pain is usually worse sitting and frequently also worse laying down (on the ipsilateral side), as well as improved in a recliner.

An SIJ injection was considered confirmatory if it produced ≥50% improvement in SIJ pain following (1) injections in the SIJ, (2) L5-S3 medial branch blocks, (3) or both.[12-14] The use of a CT scan (typically obtained for planning purposes before SIJ surgery) was not included as an inclusion/exclusion requirement because surgery on the SIJ was not contemplated during the index operation, and CT findings of SIJ degeneration are nonspecific.[15-17]

Our primary endpoint was the magnitude of change in the 10-point VAS in the region of the SIJ in patients with a minimum of 2 years of follow-up after surgery. Our analysis also included a number of secondary endpoints. Improvement of VAS scores at 3 months was used to assess how rapidly symptoms improved. Sagittal balance, measured from 36-in. scoliosis x-rays by an independent, blinded neuroradiologist was used to assess correlation between static sagittal balance and SIJ pain improvement. Patients were grouped into those with normal (≤5 cm) sagittal balance and abnormal (>5 cm).[18] Patients were grouped into those with decompression alone versus decompression and spinal (without SIJ) fusion to examine whether the addition of a spinal fusion impacted SIJ pain improvement or durability. Because our primary question sought to examine the influence of flexed posture because of claudication on the magnitude of SIJ pain, we therefore grouped all patients together. Patients were grouped into those that were diagnosed with history and physical examination findings of SIJ pain confirmed with injection versus those without injection or <50% improvement in injection to asses validity of clinical findings alone in diagnosis of SIJ pain. Paired Student's t-test was used to compare preoperative to postoperative SIJ pain VAS scores and

Table 1. Patient Demographics and Surgical Treatment

Patient*	Age	Sex	Decompression	Levels	Fusion	Levels	Instrumentation	Levels
1	79	M	Laminectomy	L1-5				
2	69	M	Laminectomy	L2-5				
3	42	F	Hemilaminectomy	R L4-5				
4	66	M	Laminectomy	L2-5				
5	64	M	Laminectomy	L2-5				
6	65	F	Hemilaminectomy	L L3-6				
7	67	M	Hemilaminectomy	L L3-5				
8	53	M	Hemilaminectomy	R L4-S1				
9	46	F	Laminectomy Hemilaminectomy	L2-5 L L5-S1				
10	82	M	Laminectomy	L4-S1	TLIF	L4-S1	Pedicle screws	L4-S1
11	66	M	Laminectomy	L1-5	TLIF	L4-5	Pedicle screws	L4-5
12	60	F	Laminectomy	L2-5	PSF	L3-5	Pedicle screws	L3-5
13	64	M	Hemilaminectomy	L5-S1	TLIF	L5-S1	Pedicle screws	L5-S1
14	60	M	Laminectomy	L5-6-S1	TLIF	L5-S1	Pedicle screws	L5-S1
15	72	F	Laminectomy	L2-5	TLIF	L4-5	Pedicle screws	L4-5
16	53	F	Laminectomy	L4-S1	TLIF	L4-S1	Pedicle screws	L4-S1
17	74	F	Laminectomy	L3-5	TLIF	L3-5	Pedicle screws	L3-5
18	67	F	Laminectomy	L4-5	TLIF	L4-5	Pedicle screws	L4-5
19	58	F	Laminectomy	L4-5	TLIF	L4-5	Pedicle screws	L4-5
20	62	F	Laminectomy	L2-5	TLIF	L3-5	Pedicle screws	L3-5

PLF, posterior lumbar fusion; TLIF, transforaminal lumbar interbody fusion.
*Patients 1–9 were treated with decompression only.

preoperative to postoperative sagittal balance. Independent samples t-test was used to compare differences in mean SIJ pain VAS score change between subgroups. Pearson correlation was performed to determine if there was a correlation between the change in radiographic sagittal balance and improvement in SIJ pain VAS scores.

RESULTS

Ten consecutive patients (3 females) met entry criteria for evaluation at a minimum of 2 years postoperatively (average, 30.7 months). Four were treated with decompression alone, and 6 with decompression and fusion (Table 1). Mean SIJ VAS score improved from before surgery by 6.9 ± 2.4 (8.7 ± 1.6–1.8 ± 2.2; $P < 0.0005$).

Twenty consecutive patients (10 females) met entry criteria for evaluation at 3 months postoperatively. Nine were treated with decompression alone, and 11 with decompression and fusion (Table 1). Mean SIJ VAS score at 3 months improved by 6.0 ± 3.0 (8.8 ± 1.4–2.8 ± 2.8; $P < 0.0005$).

To assess the time course of results, endpoints at the 3 months, 12 months, and minimum 24 months were evaluated. There was no significant difference between improvement at 3 months and all other time points.

There was no significant overall change in sagittal balance on scoliosis x-rays in all patients combined before versus after surgery (Table 2). Pearson correlation between change in sagittal balance on 36-in. standing scoliosis films and improvement in SIJ pain VAS scores demonstrated no significant correlation ($r = -0.344$, $P = 0.191$). There was no significant difference in SIJ pain VAS score improvement between patients that had normal (≤5 cm) or abnormal (>5 cm) sagittal balance (Table 3). There was no change in pelvic tilt or correlation with improvement of SIJ pain when comparing pre-to postoperative measurements on scoliosis x-rays (data not shown).

Subgroup analysis of those treated with decompression alone or decompression and spinal fusion demonstrated significant improvement in SIJ pain VAS scores in both groups. Those treated with decompression and fusion did even better than those treated with decompression alone at 3 months because of a single nonresponder in the laminectomy alone group; however, there was no difference between the 2 groups at minimum of 24 months follow-up (Table 4).

Table 2. Radiographic and Clinical Outcomes

	SVA (cm)			VAS					
Patient*	Preop.	Postop.	Δ	Preop.	3 months	Δ	≥24 months	Δ	F/U
1	9.8	10.5	0.7	10	7	3	0	10	33
2	3.9	4.1	0.2	9	4	5	4	5	27
3	-	-	-	6	3	3	0	6	27
4	-	-	-	6	2	4	0	6	28
5	-	-	-	10	0	10	-	-	18
6	4.0	4.6	0.6	8	4	4	-	-	10
7	2.6	8.2	5.6	9	9	0	-	-	9
8	-	-	-	10	7	3	-	-	8
9	0.5	−4.3	−4.8	9	5	4	-	-	4
10	3.1	2.8	−0.3	8	4	4	3	5	31
11	5.2	7.3	2.1	10	0	10	0	10	42
12	0.7	1.6	0.9	10	0	10	0	10	33
13	−1.9	1.2	3.1	8	3	5	3	5	33
14	6.9	1.4	−5.5	10	0	10	2	8	29
15	3.3	1.2	−2.1	10	5	5	6	4	24
16	−1.5	−2	−0.5	10	0	10	-	-	17
17	5.8	4.5	−1.3	8	0	8	-	-	13
18	9.1	4.1	−5	10	3	7	-	-	8
19	2.3	2.2	−0.1	8	0	8	-	-	6
20	0.0	0.9	0.9	7	0	7	-	-	8
Average	3.4	3.0	−0.3 $P = 0.65$	8.8	2.8	6 $P < 0.0005$	1.8	6.9 $P < 0.0005$	30.7

Postop., postoperative; preop., preoperative; SVA, sagittal vertical axis.
*Patients 1–9 were treated with decompression alone. Patients 10–20 were treated with decompression and spinal fusion and stabilization.

Only 2 of the 20 patients experienced treatment failure and went on to require SIJ fusion. Only 1 of the 10 to reach the time point of >2 years required SIJ fusion. The first patient (patient 7), treated with decompression alone, experienced no improvement in SIJ symptoms whatsoever, and also experienced a significant progressive worsening of sagittal balance as measured on 36-in. scoliosis x-rays. He started with positive sagittal balance, and did not want any spinal instrumentation because of his advanced yoga practice and concerns about loss of range of motion. He attempted conservative management for 4 years before the index

Table 3. SIJ Pain VAS Improvement in Patients With Normal and Abnormal Sagittal Balance

	Sagittal Balance ≤5 cm			Sagittal Balance >5 cm			Difference
n	11			5			
VAS	Preop.	Postop.	Change	Preop.	Postop.	Change	
Mean	8.7 ± 1.0	3.1 ± 2.9	5.6 ± 2.9	9.6 ± 0.9	2.0 ± 3.1	7.6 ± 2.9	2.0
P			<0.0005			0.004	0.25

VAS, visual analog scale.

Table 4. Sacroiliac Joint Pain VAS

3 Month	Decompression Alone (n = 9)			Decompression and Fusion (n = 11)			Difference
VAS	Preop.	Postop.	Change	Preop.	Postop.	Change	
Mean	8.6 ± 1.6	4.6 ± 2.8	4.0 ± 2.6	9.0 ± 1.2	1.4 ± 1.7	7.6	3.6
P			0.002			<0.0005	0.004
≥24 Month	**Decompression alone (n = 4)**			**Decompression and fusion (n = 6)**			**Difference**
VAS	Preop.	Postop.	Change	Preop.	Postop.	Change	
Mean	7.8 ± 2.1	1.0 ± 2.0	6.8 ± 2.2	9.3 ± 1.0	2.3 ± 2.3	7.0 ± 2.7	−0.3
P			0.009			0.001	0.88

laminectomy, and 18 months before SIJ fusion for a total of 66 months from the onset of the SIJ pain to SIJ fusion. SIJ pain VAS improved from 9 before SIJ fusion to 4 at 6 weeks postoperatively. The second patient (patient 12), treated with decompression and fusion, did experience complete resolution of SIJ symptoms at the 3-month interval. However, by 12 months, the VAS pain score in the SIJ returned to the preoperative level. Of note, this patient experienced an improvement in radiographic sagittal balance. Although a surgical candidate for SIJ surgery, the patient's insurance carrier does not cover this operation, so it remains unknown if surgery will help this patient. These 2 treatment failures shared no common characteristics. However, in spite of these failures, 95% of 20 patients had a marked improvement in SIJ pain at 3 months, with about 90% durability for 10 patients at >2 years after decompressive spinal surgery. The only other surgical significant adverse event involved a patient in the internal fixation group who developed painful hardware unrelated to the SIJ and required removal of the painful screw on a delayed basis.

There was no significant difference in VAS change between those with SIJ pain diagnosed clinically with confirmation by injection (n = 10) and those diagnosed clinically alone (Table 5).

DISCUSSION

This study demonstrates for the first time that SIJ pain improvement is robust, rapid, reproducible, and durable following lumbar laminectomy for stenosis with claudication accompanied by flexed posture when ambulating. This combination of lumbar stenosis with claudication, flexed posture and secondary SIJ pain (that improves after laminectomy) represents a newly described syndrome.

The history of walking in a flexed position because of claudication correlated in all cases but 1, with rapid improvement in SIJ pain postlaminectomy. In our patient population, the forward-flexed posture is adopted during ambulation in response to the lumbar stenosis with claudication symptoms. As a dynamic phenomenon, the flexed posture was not apparent on static radiographs. When not ambulating, patients with neurogenic claudication can maintain an upright posture pain-free, particularly when prompted by the radiology technician. Imaging studies to assess sagittal balance offer no further predictive benefit beyond history and physical examination in this cohort. Having normal or abnormal sagittal balance on preoperative scoliosis x-rays did not correlate with improvement in SIJ pain following surgery. Likewise, there was no correlation of pelvic retroversion and SIJ pain, further confirming that the etiology of SIJ pain is related to dynamic rather than static changes in pelvic anatomy.

The history of walking flexed by patient report, companion report, or direct observation in the clinic was used in this study as an inclusion criterion. This is not a verified or standardized entry criterion in clinical studies. However, in this study it very accurately predicted that SIJ pain from walking flexed by history would improve after decompressive surgery.

As was the case with imaging to assess sagittal balance, SIJ injections, even when pain relief was profound, offered no predictive benefit above and beyond the combined history and physical examination alone in this cohort. Criteria for the clinical diagnosis of SIJ pain in this study were more rigorous than in

Table 5. SIJ Pain VAS Improvement in Patients With and Without Confirmatory Injection

	Injection With ≥50% Improvement			No Injection			Difference
n	10			10			
VAS	Preop.	Postop.	Change	Preop.	Postop.	Change	
Mean	9.0 ± 1.1	3.1 ± 3.2	5.9 ± 3.1	8.6 ± 1.6	2.5 ± 2.5	6.1 ± 3	0.2
P			<0.0005			<0.0005	0.89

other studies.[9,10] In addition to physical examination findings, patients needed to also have numerous history findings as well as severe SIJ pain in order to be included in this study. We found no instances where our diagnosis of SIJ pain was excluded by a diagnostic block. Because of the severity of SIJ pain in all patients in the study (mean SIJ VAS, 8.2), patients typically had far more than 3 positive physical examination findings as well as 3 positive characteristic history elements. Three or more positive provocative tests alone produce 92% to 94% sensitivity and 78% to 87% specificity for the diagnosis of SIJ pain.[19] Our addition of 3 or more typical history findings, severe SIJ pain, and attention to patterns of referred pain is likely to raise the diagnostic sensitivity and specificity even higher. Additionally, once we began to observe repeated improvement in SIJ pain in initial patients following laminectomy based on clinical diagnosis alone, we added confirmatory blocks of the SIJ to our diagnostic algorithm. All 10 patients that received confirmatory blocks had a >50% transient improvement in SIJ pain, providing further evidence of the accuracy of this diagnostic algorithm. Polly et al. similarly found that reduction in SIJ pain following SIJ surgery did not correlate with reductions of SIJ pain by SIJ blocks.[20]

CT scans were not used in this study to diagnose SIJ pain because of the high rate of false-positive or false-negative findings,[15-17] combined with the lack of need to have a CT for surgical planning purposes as SIJ surgery was not contemplated before the index operation. This lack of a preoperative CT of the SIJ had no effect on the diagnostic accuracy of the algorithm used for diagnosing SIJ pain in this study, nor did it have any effect on the predictive value of which patients would improve following surgery.

The present study has several limitations. It is a small, retrospective study conducted by a single surgeon. As such, it is subject to selection bias, underpowering, and regression to the mean among other problems inherent with such trial designs. Because of the limited cohort size, the study may not have been adequately powered to demonstrate if there truly was a difference in outcomes between patients treated with decompression alone versus decompression with spinal stabilization and fusion. We did not evaluate the effects of stenosis on SIJ pain in patients where SIJ pain symptoms predated the onset of claudication symptoms.

CONCLUSION

Sacroiliac joint pain shows robust, rapid, reproducible, and durable improvement following lumbar laminectomy alone in patients with lumbar stenosis with claudication. The addition of a lumbar stabilization with fusion in patients with stenosis and claudication also leads to a similar magnitude of improvement in SIJ pain. This improvement in SIJ pain correlated highly with the history of walking flexed, but did not correlate with preoperative static scoliosis x-rays that did not capture the extent of dynamic flexion while walking. These results suggest that SIJ pain in patients with stenosis and claudication is secondary to walking in a flexed position, and improves postoperatively when patients can walk upright. Further research is needed to determine if other sagittal deformity corrections alleviate concomitant SIJ pain. Similar studies are warranted to determine if myofascial pain, which can also worsen when walking flexed, can improve with lumbar laminectomy alone. It is also necessary to validate if the combination of history and physical examination is as accurate in diagnosing SIJ pain as using physical examination, injections, and CT scans, as our preliminary data suggest.

This study demonstrates the need for an accurate diagnosis of the cause of low back pain in patients with stenosis and claudication, as SIJ pain (instead of axial pain) in the setting of walking with a flexed posture, generally improves after decompressive surgery. It is also important to delineate the specific source of low back pain in patients with low back pain and leg pain in order to plan the appropriate operation.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Thomas B. Freeman: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - original draft, Writing - review & editing, Visualization, Supervision. **Konrad Bach:** Methodology, Formal analysis, Investigation, Data curation, Writing - original draft, Writing - review & editing, Visualization, Project administration. **Ryan D. Murtagh:** Methodology, Validation, Formal analysis, Investigation, Data curation.

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