European Spine Journal (2019) 28:1603–1609
https://doi.org/10.1007/s00586-019-05952-z

ORIGINAL ARTICLE

The association between sacroiliac joint-related pain following lumbar spine surgery and spinopelvic parameters: a prospective multicenter study

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Received: 12 October 2018 / Revised: 16 February 2019 / Accepted: 13 March 2019 / Published online: 18 March 2019

Abstract

Purpose To prospectively calculate the incidence of postoperative sacroiliac joint-related pain (SIJP) and investigate the association between spinopelvic parameters and postoperative SIJP after lumbar spine surgery.

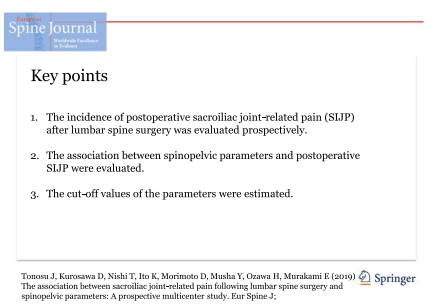
Methods We prospectively enrolled consecutive patients who underwent lumbar spine surgery. We defined postoperative SIJP as unilateral buttock pain according to fulfillment of the following criteria within 3 months of the surgery: a sacroiliac joint (SIJ) score higher than 4/9 postoperatively; positive response to analgesic periarticular SIJ injection with fluoroscopy; no other complications related to the surgery. The patients were divided into the SIJP group and non-SIJP group. We compared the background information and analyzed the differences in spinopelvic parameters in both groups. Additionally, receiver-operating characteristic curve analyses were performed to evaluate the cutoff values of spinopelvic parameters.

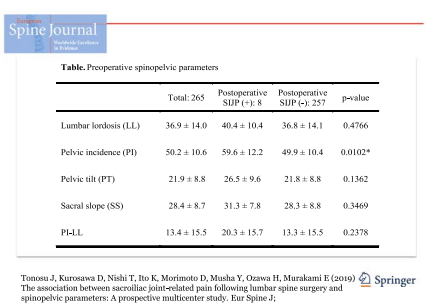
Results Of the 281 patients enrolled, 265 were included and eight developed postoperative SIJP (3.0%). There were no significant differences in the background information between groups. Preoperative and postoperative radiological evaluations revealed that the pelvic incidence (PI) in the SIJP group was significantly higher than that in the non-SIJP group, and there were no significant differences in lumbar lordosis (LL), pelvic tilt, sacral slope, and PI minus LL. For preoperative PI, the area under the curve, cutoff value, sensitivity, and specificity were 0.73739, 59, 62.5%, and 81.9%, respectively.

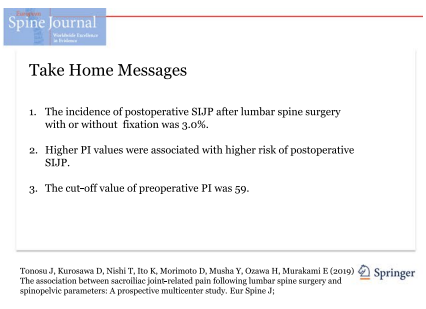
Conclusions The incidence of postoperative SIJP after lumbar spine surgery was 3.0%. Higher PI values were associated with a higher risk of postoperative SIJP.

Graphical abstract

These slides can be retrieved under Electronic Supplementary Material.







Keywords Sacroiliac joint-related pain · Lumbar spine surgery · Postoperative pain · Spinopelvic parameters · Pelvic incidence

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00586-019-05952-z) contains supplementary material, which is available to authorized users.

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Introduction

Sacroiliac joint (SIJ)-related pain (SIJP) is one of the common causes of low back pain (LBP) [1–5]. The reported incidence of SIJP in patients with LBP is 10–30% [2, 3, 5]. Deyo et al. [6] reported in the 1990s that approximately 85% of LBP is non-specific LBP, and that SIJ is one of a non-specific cause of LBP. There are no specific radiological findings of SIJP, even on magnetic resonance imaging (MRI). Therefore, a diagnosis is made based on provocation tests and determining whether relief can be achieved with analgesic block of the SIJ [1–5]. Kurosawa et al. [7] developed the SIJ pain score (SIJ score) for diagnosing SIJP and highlighted the importance of clinical findings.

Some reports have demonstrated that SIJP follows lumbar fixation surgery, which was 5.3–10.7% of the surgery [8–10]. They discussed that one of the causes of the pain was increasing mechanical stress on SIJ as a result of lumbar or lumbosacral fixation. Another report demonstrated SIJP even in lumbar decompression surgery without fixation, which was 22% of the surgery [11].

Spinopelvic alignment has been recognized as an important factor when planning lumbar surgeries. It could be associated with LBP before and after the surgery, and adjacent disk degeneration following fixation surgeries. In 1998, Legaye et al. [12] introduced the concept of pelvic incidence (PI) as a fundamental pelvic parameter for three-dimensional regulation of spinal sagittal curves. They reported that the angle of PI was equal to the sum of those of sacral slope (SS) and pelvic tilt (PT), that PI was a specified value for each person in any situation, and that a close relationship was observed between PI and SS, which strongly determines lumbar lordosis (LL). Additionally, Schwab et al. [13] proposed that the ideal LL for a person was almost the same value as PI. Furthermore, some studies reported an association between spinopelvic parameters and postoperative SIJP after lumbar fixation surgeries [8, 9]. However, these studies were retrospective and did not include non-fixation surgeries.

Materials and methods

The purpose of the current study was to evaluate the incidence of postoperative SIJP prospectively and to evaluate the association between spinopelvic parameters and postoperative SIJP.

Subjects

This study was a prospective multicenter study. Five hospitals in Japan participated in the study. We prospectively enrolled consecutive patients who underwent lumbar spine surgeries between July 2016 and September 2017. Only patients over 20 years of age were included. Surgeries with both anterior and posterior approaches were included along with thoracolumbar surgeries. Patients with infectious spondylitis or tumor in the lumbar spine and pelvis or in the lumbar intradural space were not enrolled. Details of the postoperative external fixation such as the type of brace and duration of wearing the brace were not constrained. The preoperative radiographs and patient background information were collected from their medical records including age, sex, height, weight, preoperative diagnosis, type of surgery, and whether there had been hip osteoarthritis or hip surgery on either side. Body mass index (BMI) was calculated using the height and weight data. Details of the procedures were collected, such as whether fixation was performed, the number of fixation level(s), the number of decompression level(s), and whether the iliac bone was harvested. The preoperative SIJ scores (on a nine-point scale) for all enrolled patients were evaluated. In the analyses, those with scores >4 points were excluded because we regarded those as cases with lumbar diseases with SIJP preoperatively, in reference to the report on the cutoff value of the SIJ score [7]. Furthermore, patients with hip osteoarthritis of either side and those with a history of hip surgery were also excluded. We evaluated both preoperative and postoperative spinopelvic parameters such as LL, PI, PT, SS, and PI minus LL (PI − LL), based on standing radiographs, for which the subjects were asked to relax their necks while looking straight ahead, without pulling in the chin and with their hands on the clavicles. One observer in each hospital performed the measurements. Postoperative radiographs were taken 1 week after the surgery. The SIJP group was defined as the group of patients who experienced postoperative unilateral buttock pain and fulfilled the criteria described below. The non-SIJP group was defined as those who were other than the SIJP group. We compared the groups and analyzed the differences in preoperative and postoperative spinopelvic parameters between them. Additionally, receiver-operating characteristic (ROC) curve analyses were performed to evaluate the cutoff values of spinopelvic parameters that were significantly different between the groups. This study was approved by the medical/ethics review boards of all five hospitals. Informed consent was obtained from all individual participants included in the study.

Definition of postoperative sacroiliac joint-related pain

We precisely defined, and evaluated, the region of the buttock pain as the area between the posterior iliac crest and the inferior gluteal fold. Although there is no consensus on diagnosing SIJP, we defined postoperative SIJP as unilateral buttock pain that fulfills the following criteria within 3 months of the surgery: SIJ score > 4 [7]; positive response to analgesic periarticular SIJ injection with fluoroscopy; no misplacement of implants on lumbar computed tomography (CT); no residual compression findings of the nerve roots and cauda equina on lumbar MRI; and no surgical site infection suspected by lumbar MRI and blood examination. There also was no consensus regarding the onset of postoperative SIJP. We defined the endpoint as 3 months after the operation because we assumed that it is unclear whether an SIJP that occurs a long time after lumbar surgery is related to the surgery.

A previous study on diagnosing SIJP using the scoring of clinical findings reported that SIJ score was the sum of scores of the following six items [7]: one-finger test (3 points) [14], groin pain (2 points), pain while sitting on a chair (1 point), SIJ shear test (1 point) [1], tenderness of the posterosuperior iliac spine (PSIS) (1 point), and tenderness of the sacrotuberous ligament (1 point). The scores, ranging from 0 to 9 points, had a cutoff value of 4. The one-finger test result is positive when a patient points the index finger to the PSIS or within 2 cm of it, as the main site of pain [14]. Analgesic SIJ injection is a 3-mL injection of 1% lidocaine into the periarticular space of SIJ with fluoroscopic control [4, 15, 16]. The degree of buttock pain both before and after the injection was evaluated. According to a previous study, when the pain improves by more than 70%, 15 min after the injection, we defined it as a positive reaction to the analgesic injection [7]. Improvements in pain were evaluated by directly asking patients to score their pain levels on a scale of 0 (pain-free) to 10. When a score before the injection was hypothesized as 10, a score of ≤ 3 after the injection was interpreted as an improvement of more than 70%.

Statistical methods

Descriptive statistics were determined and presented as means and standard deviations or frequencies and percentages. Inter-group differences in the baseline values were evaluated using Fisher's exact test or Chi-square test for categorical variables, while Student's *t* test was used for continuous variables. We calculated the area under the ROC curve (AUC), sensitivity, and specificity. AUC of 1.0 indicated perfect discrimination. In general, accuracy was interpreted as follows: high, 0.9 ≤ AUC < 1.0; moderate, 0.7 ≤ AUC < 0.9; and low, 0.5 ≤ AUC < 0.7. Statistical power analyses were performed by calculating the diagnostic prediction performances about each spinopelvic parameter. Statistical analyses were performed using JMP 11.0 software program (SAS Institute, Cary, NC, USA); $p < 0.05$ was considered significant.

Results

We prospectively enrolled 281 patients; of these, 12 with SIJ score > 4, six with hip osteoarthritis or history of hip surgeries were excluded. Two patients satisfied both the exclusion criteria. Therefore, 265 patients were included. Eight of them developed postoperative SIJP, resulting in an incidence of 3.0%. There were no significant differences between the SIJP group and the non-SIJP group regarding their demographic data (Table 1). There were also no significant differences regarding the number of decompression levels (1.4 in the SIJP group vs. 1.5 in the non-SIJP group, $p = 0.5918$), the number of fixation levels (0.3 vs. 0.7, $p = 0.4063$), and harvesting of the iliac bone (0% vs. 3.0%, $p = 1.0000$). Lumbar spinal stenosis was seen in approximately two-thirds of the patients, followed by lumbar disk herniation in about one-fourth. There were no significant differences in the preoperative diagnoses between the groups ($p = 0.7917$) (Table 2). Details of the eight patients who developed postoperative SIJP are summarized in Table 3. None of the thirty patients who underwent L5/S1 fixation developed postoperative SIJP. Preoperative radiological evaluation revealed that PI in the SIJP group was significantly higher than those in the non-SIJP group, while there were no significant differences in LL, PT, SS, and PI–LL (Table 4). Postoperative radiological evaluation revealed similar results (Table 5). The differences between the preoperative PI and the

Table 1 Demographic data of the patients

	Total: 265	Postoperative SIJP (+): 8	Postoperative SIJP (−): 257	*p* value
Age	63.3 ± 15.5	66.9 ± 15.1	63.2 ± 15.5	0.5120
Sex				
Female	98 (37.0)	3 (37.5)	95 (37.0)	1.0000
Male	167 (63.0)	5 (62.5)	162 (63.0)	
BMI (kg/m^2)	23.9 ± 3.6	22.7 ± 2.8	23.9 ± 3.6	0.3597
Fixation surgery				
(+)	90 (34.0)	1 (12.5)	89 (34.6)	0.2720
Preoperative SIJ score	0.8 ± 1.2	0.6 ± 0.7	0.8 ± 1.2	0.7559

Data are shown as mean ± SD or number of participants (%)

BMI body mass index, *SIJ* sacroiliac joint, *SIJP* sacroiliac joint-related pain

Table 2 Preoperative diagnosis for the surgeries

	Total: 265	Postoperative SIJP (+): 8	Postoperative SIJP (−): 257
Lumbar spinal stenosis	177 (66.8)	7 (87.5)	170 (66.1)
Lumbar disk herniation	70 (26.4)	1 (12.5)	69 (26.8)
Adult spine deformity	5 (1.9)	0 (0.0)	5 (2.0)
Spondylolytic spondylolisthesis	4 (1.5)	0 (0.0)	4 (1.6)
Others	9 (3.4)	0 (0.0)	9 (3.5)

Data are shown as number of participants (%)

SIJP sacroiliac joint-related pain

postoperative PI were 0.2° in the SIJP group and zero in the non-SIJP group, respectively. In addition, those were 0.1° in patients older than 65, and 0.4 degree in patients younger than 65, of the all patients. The AUCs of preoperative and postoperative PI in ROC analyses were 0.73739 and 0.73649, while the cutoff values were 59 and 57, the sensitivities were 62.5 and 71.4, and the specificities were 81.9 and 76.7, respectively. The calculated statistical powers of the preoperative and postoperative PIs were 0.7322 and 0.6562, respectively.

Discussion

The incidence of SIJP following lumbar operations was 3.0%, which was lower than that previously reported [8–10]. The difference could be attributed to the strict definition of SIJP and the prospective evaluation in the current study. Preoperative evaluation of SIJ scores in all patients was a strength in this study. A previous observational study reported that SIJP was often a co-existing comorbidity with other lumbar diseases [17]. We could identify such cases preoperatively and excluded them from the materials of the current study. Therefore, the preoperative SIJ scores were not significantly different between the SIJP group and the non-SIJP group. Preoperative diagnoses were not also

Table 4 Preoperative spinopelvic parameters

	Total: 265	Postoperative SIJP (+): 8	Postoperative SIJP (−): 257	*p* value
Lumbar lordosis (LL)	36.9 ± 14.0	40.4 ± 10.4	36.8 ± 14.1	0.4766
Pelvic incidence (PI)	50.2 ± 10.6	59.6 ± 12.2	49.9 ± 10.4	0.0102*
Pelvic tilt (PT)	21.9 ± 8.8	26.5 ± 9.6	21.8 ± 8.8	0.1362
Sacral slope (SS)	28.4 ± 8.7	31.3 ± 7.8	28.3 ± 8.8	0.3469
PI–LL	13.4 ± 15.5	20.3 ± 15.7	13.3 ± 15.5	0.2378

*$p < 0.05$

Data are shown as mean ± SD

SIJP sacroiliac joint-related pain

Table 5 Postoperative spinopelvic parameters

	Total: 265	Postoperative SIJP (+): 8	Postoperative SIJP (−): 257	*p* value
Lumbar lordosis (LL)	39.9 ± 12.6	42.0 ± 11.5	39.9 ± 12.6	0.6399
Pelvic incidence (PI)	50.2 ± 10.6	59.4 ± 11.5	49.9 ± 10.4	0.0186*
Pelvic tilt (PT)	20.8 ± 7.9	24.1 ± 9.1	20.7 ± 7.9	0.2273
Sacral slope (SS)	29.6 ± 8.6	31.6 ± 8.3	29.5 ± 8.6	0.4930
PI–LL	10.5 ± 14.1	18.1 ± 17.1	10.2 ± 13.9	0.1421

Data are shown as mean ± SD

SIJP sacroiliac joint-related pain

*$p < 0.05$

Table 3 Details of the cases that developed postoperative sacroiliac joint-related pain

No.	Age	Sex	Diagnosis	Procedure	Level(s) of the operation	Onset from the operation	Preoperative SIJ score	Postoperative SIJ score
1	71	F	Lumbar spinal stenosis	Decompression	L4/5	4 weeks	0	6
2	58	M	Lumbar spinal stenosis	Decompression	L2/3	1 week	1	7
3	83	M	Lumbar spinal stenosis	Decompression	L4/5	4 days	1	6
4	51	F	Lumbar spinal stenosis	Decompression and fixation	L3/4/5	1 week	0	8
5	75	M	Lumbar spinal stenosis	Decompression	L3/4/5	1 week	0	7
6	76	M	Lumbar spinal stenosis	Decompression	L3/4/5	2 weeks	0	5
7	80	M	Lumbar spinal stenosis	Decompression	L4/5	4 weeks	1	5
8	40	F	Lumbar disk herniation	Herniotomy	L5/S1	3 days	2	6

SIJ sacroiliac joint

significantly different between the two groups. Therefore, there were no significant differences in the background characteristics between the two groups.

The diagnosis of SIJP has not been clearly established and remains a challenge [1–5]. We adopted both the SIJ score [7] and the analgesic periarticular SIJ injection to diagnose it. Some reports have demonstrated that the posterior ligament region is a significant source of SIJP [18–20]. Additionally, a recent report showed that periarticular SIJ injection should be performed first to treat SIJP, and only if it is not effective, should an intra-articular injection be administered [16]. Therefore, we adopted the method of periarticular SIJ injection. Of the eight cases of SIJP following lumbar surgeries, only one included fixation surgery; the fixation was performed at L3/4/5 levels, without including L5/S1. Although there have been some reports that postoperative SIJP could result in adjacent segment degeneration of lumbosacral fixation [10, 21], according to our results, there could be other mechanisms for postoperative SIJP. A report on the postoperative SIJP following decompression surgery without fixation discussed that the reason might be a change in the sagittal alignment of the lumbar spine; however, the spinopelvic parameters were not measured using radiography in that study [11]. The postoperative spinopelvic parameters were not changed much compared with the preoperative parameters in our study. A possibility is that the true change in the posture was not detectable in the static evaluation based on standing radiographs. The true change might be evaluated using dynamic motion analysis. The onset of SIJP varied from 4 days to 4 weeks after the surgery. There were not many studies about the onset [10]. There could be mainly pain around the wound site immediately after the surgery, even with SIJP; however, our results might suggest that increasing activity was related to the onset.

The high preoperative PI was related to the development of postoperative SIJP. PI is an inherent value in each person and is not affected by posture and aging [12]. The preoperative and postoperative PI values were almost same in both the SIJP group and the non-SIJP group. A study about long spinal fusion showed that PIs were changed after the surgeries, especially in the group who had fusion from the thoracic spine to sacrum without pelvic fixation in their age of more than 65, and discussed that these changes could be related to degeneration of the SIJs causing increased rotational mobility [22]. Our results did not correspond with the result of the study. It could be attributed to that fixation surgeries to sacrum in our study were only 11% of all cases. Studies, using three-dimensional (3D) standing radiographic analyses, have established that the mean PI value in Japanese volunteers was similar to that in Caucasian people as 52.3° [23, 24]. Another study in Japanese asymptomatic individuals showed that the mean PI was 53.7° [25]. While the PI value of the non-SIJP group in our study was similar to the normative value, that of the SIJP group was higher. PI is a sum of PT and SS; therefore, both preoperative PT and SS tended to be higher in the SIJP group than in the non-SIJP group. However, there were no significant differences in both PT and SS. Small LL and large PI–LL are often seen in patients with lumbar diseases such as spinopelvic imbalance [13]. The patients in this study showed such an imbalance; however, both LL and PI-LL were not related to the development of postoperative SIJP.

The higher postoperative PI was also related to the development of postoperative SIJP. Both the postoperative PT and SS were similar to the preoperative ones, which was because of fewer cases of corrective procedures for spinopelvic alignment. Therefore, those were also not related to postoperative SIJP. The mean increase in LL postoperatively in these patients was approximately 3°, which matched the mean decrease in PI–LL. Since fixation surgeries accounted for only 34% of all surgeries in the current study, correction of LL was limited. Postoperative spinopelvic imbalance was not related to either the development of postoperative SIJP as well as preoperative spinopelvic imbalance. Previous studies have showed that postoperative SIJP was related to insufficient improvements in large PT and small LL [8, 9], which was not observed with our results.

There are some studies on the relationship between sagittal spinopelvic alignment and LBP in the general population. Although a report has shown that low PI, SS, and LL were related to LBP [26], another report showed that high PI and SS were related to LBP, especially in females [27]. Both studies did not define the area of the LBP; therefore, participants with LBP could actually have been suffering from SIJP in both studies. Our result corresponded partly with the result of the latter study. A posterior shift in shearing force line, resulting from a high PI, may put a load on the posterior components of the low back, followed by an increase in LBP [28]. The posterior components include the facet joints as well as SIJ; therefore, postoperative facet joint pain in high PI cases could also increase, theoretically. However, we did not focus on facet joint pain. Careful postoperative evaluation using both the SIJ score and analgesic periarticular SIJ injection could exclude facet joint pain in the current study.

Finally, our results demonstrated that the high PI was related to the development of postoperative SIJP regardless of fixation procedures. AUC of 0.73739 and 0.73649 in the ROC analyses of the preoperative and postoperative PI in the current study was considered to indicate moderate accuracy. The cutoff value of preoperative PI was 59. Therefore, we could recommend that a high index of suspicion for postoperative SIJP must be maintained in cases with preoperative PI > 59.

There are some limitations to this study. First, the incidence was low for the analyses. The calculated statistical powers of 0.7322 and 0.6562 would increase if the sample

size was large. The enrollment had been done for 1 year and 3 months; therefore, we prioritized analyzing the results at that point rather than waiting for an increase in the SIJP cases. Second, there could be false-positive responses to the analgesic injection in the postoperative diagnoses. Some reports have reported an incidence of false-positive responses to the analgesic SIJ injection of 10–20% [15, 29]. Although we performed diagnostic injection just once, multiple injections for diagnosis would increase diagnostic accuracy. Third, there was selection bias in our patients. Patients from these five hospitals cannot represent all the patients in other parts of the world who undergo lumbar surgeries. Fourth, measurement error of the spinopelvic parameters was not evaluated. If intra-observer and inter-observer reliabilities were evaluated, the presented parameters would have been more reliable.

Conclusions

The incidence of SIJP following lumbar spine surgeries with or without fixation was 3.0%. The preoperative and postoperative higher PI values were significantly associated with postoperative SIJP, although the statistical powers were somewhat low. Other parameters such as LL, PT, SS, and PI–LL were not associated with SIJP.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Acknowledgements We thank the medical clerks at the hospitals for collecting the data.

Compliance with ethical standards

Conflict of interest All authors have no conflict of interests to declare.

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