Is There a Relationship Between Body Mass Index and Fluoroscopy Time During Sacroiliac Joint Injection? A Multicenter Cohort Study

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Abstract

Objective. To determine the relationship between BMI and fluoroscopy time during intra-articular sacroiliac joint (SIJ) injections performed for a pain indication.

Design. Multicenter retrospective cohort study.

Setting. Three academic, outpatient pain treatment centers.

Subjects. Patients who underwent fluoroscopy guided SIJ injection with encounter data regarding fluoroscopy time during the procedure and body mass index (BMI).

Main Outcome Measure. Median and 25–75% Interquartile Range (IQR) fluoroscopy time.

Results. 459 SIJ injections (350 patients) were included in this study. Patients had a median age of 57 (IQR 44, 70) years, and 72% were female. The median BMI in the normal weight, overweight, and obese groups were 23 (IQR 21, 24), 27 (IQR 26, 29), and 35 (IQR 32, 40), respectively. There was no significant difference in the median fluoroscopy time recorded between these BMI classes (p = 0.45).

First-time SIJ injection (p = 0.53), bilateral injection (p = 0.30), trainee involvement (p = 0.47), and new trainee involvement (trainee participation during the first 2 months of the academic year) (p = 0.85) were not associated with increased fluoroscopy time for any of the three BMI categories.

Conclusions. Fluoroscopy time during sacroiliac joint injection is not increased in patients who are overweight or obese, regardless of whether a first-time sacroiliac joint injection was performed, bilateral injections were performed, a trainee was involved, or a new trainee was involved.

Key Words. Sacroiliac Joint; Injections; Obesity; Overweight; Body Mass Index; Fluoroscopy; Radiation

Introduction

Chronic low back pain is a major public health problem affecting over 100 million adults per year [1] and estimated to originate from the sacroiliac joint in up to 10–25% of cases [2,3]. Fluoroscopy-guided spine injections, including intra-articular sacroiliac joint (SIJ) injections, are commonly used in the treatment of chronic low back pain [4,5]. Common co-morbidities in
individuals with low back pain include cardiovascular disease, asthma, headache/migraine, osteoporosis, and mood disorders [6–8]. Obesity is perhaps the most common comorbidity in individuals with chronic low back pain [9], and thus, clinicians must frequently make treatment and procedural decisions in the context of these concomitant diagnoses. Higher body mass index (BMI) is associated with greater challenges in obtaining high quality medical imaging in addition to increased radiation doses [10,11]. Single exposure and cumulative radiation exposure are potential safety hazards to both patients and healthcare providers. The surgical, endovascular and interventional cardiology literature have demonstrated longer fluoroscopy times and a greater risk for radiation exposure as a result of increased BMI [12–17] but few studies have analyzed the relationship between BMI, fluoroscopy times, and radiation exposure during interventional spine injections for pain management [18,19], and only one small, underpowered study of these factors related to SIJ injections has been published [19].

In this study, we aimed to determine the relationship between BMI and fluoroscopy time during SIJ injections performed for a pain indication.

Methods

The Northwestern University Institution Review Board approved this multicenter retrospective cohort study. Electronic medical records of patients at three academic, outpatient pain treatment centers in the Midwest were surveyed using current procedural terminology (CPT) code 27096 to identify eligible procedures for analysis. These centers included The Rehabilitation Institute of Chicago (RIC) Sports and Spine Rehabilitation Center, the RIC Sports and Spine Center at River Forest, and the Northwestern Memorial Faculty Foundation (NMFF) Anesthesiology Pain Medicine Center. The RIC Sports and Spine Center and the Spine Center at River Forest are both under the umbrella institution of RIC (affiliated but not a part of the Northwestern University hospital system), thus there was some attending physician and trainee overlap between The RIC Sports and Spine Center and RIC Spine Center at River Forrest, though less than 25%. The NMFF Anesthesiology Pain Medicine Center is a distinct practice that is part of a distinct institution (Northwestern University) with no overlap of attending physicians or trainees with RIC. Patients treated at the RIC sites between April 2007 and October 2014, and the NMFF site between January 2014 and February 2015 were included if they met inclusion criteria: 1) underwent a fluoroscopy-guided SIJ injection, 2) had a documented fluoroscopy time from the procedure, and 3) had a documented height and weight measurement or a BMI calculation. Patients undergoing SIJ injections that did not meet these criteria were excluded.

All procedures were performed in an academic teaching facility. All attending physicians who performed SIJ injections were either board-certified in Physical Medicine and Rehabilitation, with additional subspecialty board-certification in either Pain Medicine or Sports Medicine, or board certified in Anesthesiology, with additional subspecialty board certification in Pain Medicine. A total of 21 physicians with 1 to 38 years of clinical experience performed the SIJ injections. Trainees in an ACGME accredited Physical Medicine and Rehabilitation residency, Anesthesiology residency, Sports Medicine fellowship, or Multidisciplinary Pain Medicine fellowship participated in the SIJ injection procedure in 67% of cases. An attending physician supervised and/or personally performed all of the injections.

Demographic and procedural data were collected from the electronic medical record including age, sex, BMI, procedure side, unilateral or bilateral procedure, needle length used, trainee involvement, and fluoroscopy time.

Procedures

At all three study sites, the following protocol was used during SIJ injections: patients were positioned prone on a fluoroscopy table and the sacroiliac region was prepped with chlorhexidine and draped in a standard sterile manner. After local anesthesia to the skin and subcutaneous tissues superficial to a planned target site, a sterile, variably long 1.5–6.0 inch, 22- or 25-gauge spinal needle was positioned using fluoroscopic guidance at the inferior sacroiliac joint recess. Correct needle placement was confirmed in both anterior-posterior (A/P) and oblique fluoroscopic views following negative aspiration and injection of approximately 0.3–0.5 mL of contrast through microbore tubing in order to obtain an arthrogram. As true entry into the SIJ capsule is a technically challenging procedure and not realistically possible in all patients, if an arthrogram could not be achieved after a reasonable number of needle placement attempts including needle bevel rotation, withdrawal and adjustment, as well as alternative joint approaches, then a peri-articular needle placement at the inferior-posterior portion of the SIJ was accepted. The reasonable number of attempts was determined by the attending physician (typically at least three readjustments). A lateral fluoroscopic view was obtained in some cases, typically when an arthrogram was not definitive on A/P or oblique views. One mL of triamcinolone acetonide (40mg/mL) or methylprednisolone acetate (40mg/mL) diluted in 0.5–1.0 mL of various combinations of 1–2% lidocaine or 0.25–0.5% bupivacaine was administered through microbore tubing. The total volume of Injectate and contrast injected ranged from 1.8 to 2.5 mL, as has previously been recommended [20,21]. For bilateral procedures, the steps after skin prep and draping were repeated.

Blinded Independent Chart Review

In order to estimate the rate of successful SIJ injection, which could potentially influence fluoroscopy time, a blinded observer (CS) from an institution not involved in
the study reviewed fluoroscopic images from 10 consecutive SIJ injections at each of the two parent institutions in the study (RIC and NMFF; total of 20 injections). The blinded independent observer was fellowship-trained in Pain Medicine and has had over 10 years of experience interpreting interventional fluoroscopic images. This reviewer was not told anything about the purpose of the study, but only asked to categorize each injection based on a final fluoroscopic image after contrast injection during SIJ injection. No additional identifying information was included on the images. The categories were: 1) definite arthrogram, 2) possible arthrogram, or 3) unlikely arthrogram. All images were A/P or slightly oblique views. No lateral views were available in these 20 consecutive injections.

**Statistical Analysis**

Statistical software was used to analyze the data (PSPP, Version 0.8.4; Gnu Project, Boston, MA). Data were checked for implausible values and distributional form using summary statistics and graphical displays. As data were not normally distributed, nor were they when log-transformed, medians and 25–75% interquartile ranges (IQR) were calculated. Data were additionally stratified into three BMI categories: normal (BMI 18.5–24.9 kg/m²), overweight (BMI 25.0–29.9 kg/m²), and obese (BMI between ≥30.0 kg/m²). Groups were compared with Mann-Whitney U tests for continuous variables and χ² tests for categorical variables. Continuous variables were additionally compared by use of the Spearman’s rank correlation coefficient. The level of significance was set at 0.05. Two-sided testing was used for all hypothesis testing.

**Results**

Demographic and procedural characteristics of the study population are shown in Table 1. A total of 576 SIJ injections were identified for the study time frame. Of this number, 117 (20%) injections were excluded due to missing BMI data or fluoroscopy time data in the electronic medical record. Thus, 459 SIJ injections (350 patients) were included for analysis in this study.

Patients had a median age of 57 (IQR 44, 70) years, and 72% were female. The median BMI in the normal weight, overweight, and obese groups were 23 (IQR 21, 24), 27 (IQR 26, 29), and 35 (IQR 32, 40), respectively. Overweight patients were more likely to be male, whereas normal weight and obese patients were more likely to be female (p = 0.01). Obese patients had a higher baseline pre-injection numeric pain score (p < 0.01), though this difference was not clinically significant (NRS difference < 2 points) [22].

The relationship between fluoroscopy time during SIJ injection and BMI stratified by normal weight, overweight, and obese categories is shown in Table 2; this relationship, stratified by five BMI categories is shown in Figure 1. With regard to the primary analysis across the three BMI categories of normal weight, overweight, and obese, there was no significant difference in the median fluoroscopy time recorded between these BMI classes (p = 0.45). Trainee involvement was not associated with increased fluoroscopy time for any of the three BMI

**Table 1** Subject characteristics and procedure details; stratified by normal (BMI 18.5–24.9 kg/m²), overweight (BMI 25.0–29.9 kg/m²), and obese (BMI between ≥30.0 kg/m²) body mass index

<table>
<thead>
<tr>
<th>Variable</th>
<th>All patients</th>
<th>Normal weight n = 174</th>
<th>Overweight n = 151</th>
<th>Obese n = 134</th>
<th>Normal weight vs. obese P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y; median (IQR)</td>
<td>57 (44, 70)</td>
<td>54 (39, 71)</td>
<td>56 (44, 71)</td>
<td>59 (50, 68)</td>
<td>0.11</td>
</tr>
<tr>
<td>Gender, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>329 (72%)</td>
<td>135 (78%)</td>
<td>95 (63%)</td>
<td>99 (74%)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>130 (28%)</td>
<td>39 (22%)</td>
<td>56 (37%)</td>
<td>35 (26%)</td>
<td></td>
</tr>
<tr>
<td>BMI, kg/m²; median (IQR)</td>
<td>26 (2.3)</td>
<td>23 (21, 24)</td>
<td>27 (26, 29)</td>
<td>35 (32, 40)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Procedure side</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>173 (38%)</td>
<td>53 (36%)</td>
<td>66 (48%)</td>
<td>54 (49%)</td>
<td>0.06</td>
</tr>
<tr>
<td>Right</td>
<td>222 (62%)</td>
<td>94 (64%)</td>
<td>71 (52%)</td>
<td>57 (51%)</td>
<td></td>
</tr>
<tr>
<td>Trainee Involvement</td>
<td>306 (67%)</td>
<td>117 (67%)</td>
<td>95 (62%)</td>
<td>94 (71%)</td>
<td>0.33</td>
</tr>
<tr>
<td>Repeat Injection</td>
<td>148 (32%)</td>
<td>54 (31%)</td>
<td>44 (29%)</td>
<td>50 (38%)</td>
<td>0.29</td>
</tr>
<tr>
<td>Length of needle, inches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>1.5</td>
<td>5 (1%)</td>
<td>4 (2%)</td>
<td>1 (1%)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>6 (1%)</td>
<td>4 (2%)</td>
<td>2 (1%)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>428 (93%)</td>
<td>164 (95%)</td>
<td>147 (98%)</td>
<td>117 (88%)</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>16 (4%)</td>
<td>1 (&lt;1%)</td>
<td>0</td>
<td>15 (11%)</td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td>1 (&lt;1%)</td>
<td>0</td>
<td>0</td>
<td>1 (1%)</td>
<td></td>
</tr>
</tbody>
</table>

IQR – 25–75% Interquartile Range.
categories (p = 0.47). There was a significant correlation between increased fluoroscopy time and injection date earlier in the academic year (starting July 1 of each year) (Spearman’s rho = -0.12, p < 0.01); however, the presence of new trainee involvement during injection (defined as a trainee participating during the first two months of the academic year) was not associated with increased fluoroscopy time in any BMI category (p = 0.85). Needle length was directly correlated with BMI (p < 0.01), but needle length did not correlate with fluoroscopy time (p = 0.49).

Two adverse events occurred that required the procedure to be aborted: one due to a vasovagal episode

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**Table 2** Median and 25–75% Interquartile ranges (in parentheses) of fluoroscopy time during Sacroiliac joint injection for normal (BMI 18.5–24.9 kg/m²), overweight (BMI 25.0–29.9 kg/m²), and obese (BMI between ≥30.0 kg/m²) individuals. Subanalysis of repeat injections, bilateral injections, injections performed with trainee involvement, and injections performed with a new trainee (July/August procedure) are shown.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fluoroscopy time per injection, s; median (IQR)</th>
<th>Fluoroscopy time per injection, s; median (IQR)</th>
<th>Fluoroscopy time per injection, s; median (IQR)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All injections</td>
<td>18 (11, 29)</td>
<td>18 (12, 31)</td>
<td>20 (12, 31)</td>
<td>0.45</td>
</tr>
<tr>
<td>Repeat injections</td>
<td>15 (10, 27)</td>
<td>16 (11, 42)</td>
<td>19 (11, 31)</td>
<td>0.53</td>
</tr>
<tr>
<td>Bilateral injections</td>
<td>16 (11, 25)</td>
<td>13 (8, 18)</td>
<td>22 (9, 32)</td>
<td>0.30</td>
</tr>
<tr>
<td>Trainee involvement</td>
<td>18 (12, 24)</td>
<td>19 (12, 32)</td>
<td>21 (12, 30)</td>
<td>0.47</td>
</tr>
<tr>
<td>New trainee involvement</td>
<td>19 (14, 23)</td>
<td>18 (10, 22)</td>
<td>18 (9, 33)</td>
<td>0.85</td>
</tr>
</tbody>
</table>

IQR – 25–75% Interquartile Range.
New trainee – injection performed with trainee in July or August.
and one due to intolerable procedural pain that resolved after aborting the procedure. No serious adverse events occurred.

External Blinded Independent Chart Review

The two sets of 10 consecutive SIJ injections (20 total), were categorized: 10 “definite arthrograms,” 7 “possible arthrograms,” and 3 “unlikely arthrograms.” The 10 consecutive SIJ injections at RIC were categorized: 5 “definite arthrograms,” 3 “possible arthrograms,” and 2 “unlikely arthrograms.” The 10 consecutive SIJ injections at NMFF were categorized: 5 “definite arthrograms,” 4 “possible arthrograms,” and 1 “unlikely arthrogram.”

Discussion

The most important finding in this study of 459 SIJ injections is that there was no relationship between BMI and fluoroscopy time. This is an unexpected finding and contradicts prior literature. Smuck et al. reported fluoroscopy time data collected during two prospective cohort studies (total n = 137) of spine injection procedures that included zygapophyseal joint injections, medial branch nerve blocks, and transforaminal epidural steroid injections. Their comparison of normal weight (BMI 18.5 – 24.9 kg/m²) and overweight (BMI ≥ 25.0 kg/m²) patients revealed a mean of 3 additional seconds per procedure (30% increase) (p = 0.03) in the overweight group (18). In another prospective cohort study (n = 127) that included a similarly heterogeneous mix of injection types and anatomic locations, Hanu-Cernat et al reported a weak correlation between weight (though not BMI) and fluoroscopy dose per unit area (Spearman’s correlation coefficient r = 0.23, p < 0.05) [19]. This study was not designed to detect a relationship between fluoroscopy time and BMI for SIJ injections, as only 13 of the cases were of this type. The present study suggests that unlike other types of interventional spine procedures, fluoroscopy time during SIJ injection is no greater in patients with a higher BMI. It is unclear why this might be the case. To speculate, given the complex orientation and asymmetry of the sacroiliac joint as well as the lack of key neurovascular structures in close proximity, it may be the majority of the time spent optimizing needle location is spent accessing the joint rather than traversing soft tissue. In contrast, during transforaminal epidural steroid injection, for example, soft tissues are cautiously traversed in order to avoid the spinal nerve, radicular artery, dura, and intervertebral disc. Thus, while patients with higher BMI have more soft tissue to traverse, this additional distance may not be relevant for joint injections that are far from neurovascular structures of concern. These findings could be confirmed with prospective studies, but would require large numbers of participants.

In general, our findings quantify the typical fluoroscopy time required for SIJ injections and are consistent with prior studies using much smaller sample sizes [19,23–25]. The present findings demonstrate a median (IQR) fluoroscopy time of 18 [12,30] seconds (95% Confidence Interval [CI] 17 – 19), which is within the range that has been previously reported (4–51 seconds) [19,23–25]. As the present data represents the largest sample to date, these findings likely represent a more accurate representation of typical fluoroscopy time during SIJ injection in an academic interventional spine or pain practice. Notably, there was less variability in fluoroscopy time in the sample compared to prior studies, despite trainee involvement.

It is important to note that while the present data demonstrated similar fluoroscopy time in patients within a large range of BMIs, greater radiation exposure per unit of time likely occurred in patients with a higher BMI, as electrical current must be increased to allow for deeper tissue penetration in patients with higher BMI [26,27], particularly in the lateral view [28]. Other investigation has directly measured radiation dose rather than fluoroscopy time during SIJ injection. Mean radiation doses range from 12 to 108 mSv when using non-pulsed fluoroscopy [29–31], and one study reported the use of pulsed fluoroscopy (4/sec = 7.5, 60 mA, 75–80 kV), which was associated with a mean radiation dose of 4 mSv [32]. These data indicate that the amount of radiation exposure occurring during SIJ injection is within an acceptable range according to position statements by the American Association of Physicists in Medicine and the Health Physics Society, which state that radiation doses below 50-100 mSv are too low to be detectable and any estimation of adverse health consequences remain speculative [33,34]. While these data indicate that physicians should certainly not regress to using blind SIJ injections in order to avoid radiation exposure, these studies did not address radiation dose relationship with BMI. Further study of the total radiation dose in obese individuals during fluoroscopy-guided SIJ injection is needed.

While the results of this study did not that suggest patient obesity increases the radiation risks of sacroiliac joint injection, those risks are always important to consider. Patients typically do not receive multiple fluoroscopy-guided SIJ injections in close temporal proximity, however, medical staff performing or involved in these procedures are potentially exposed to this radiation on a regular basis. While the radiation scatter and absorption by staff in the fluoroscopy suite during an individual procedure may be within a safe range [33,34], it remains important to minimize potential cumulative exposure. Previous estimates of radiation exposure to the operator during fluoroscopy-guided interventional spine procedures indicate that the impact of obesity is concerning when summated over the course of a physician’s career [18], given that the risk of cataracts and a variety of cancers is associated with cumulative lifetime exposure to ionizing radiation [35–37]. Thus, performing fluoroscopy procedures on the obese patient population may increase health risks for practitioners.

Mechanisms of reducing staff radiation exposure during interventional spine procedures have been described.

Sacroiliac Joint Injection Fluoroscopy Time–BMI Relationship
extensively elsewhere [23,24,38–41]. Specific recommendations for reducing fluoroscopy radiation dose exposure in obese patients include: image collimation, avoidance of image magnification, increasing the camera aperture or electronic gain on the video amplifier rather than increasing current to improve image brightness, and use of pulsed imaging [26,32,42,43], in addition to general recommendations regarding lead shielding, and increasing distance from the C arm image intensifier [37]. Evidence exists for superior radiation dose reduction when using a low-dose CT-guidance protocol rather than fluoroscopy during other large joint [44] or axial injections [43,45], which may be considered if equipment is available. Ultrasound guidance during SIJ and other axial injection has been investigated, a technique that does not require radiation exposure [46,49]. However, this method does appear to compromise SIJ injection accuracy compared to fluoroscopy-guidance [46,50]. As ultrasound technology and techniques continue to improve, further comparative study with radiation-associated image guided techniques for SIJ and other axial injections will be important.

**Study Limitations**

The findings of this study should be understood within the context of its limitations. Multiple physicians and radiology technicians of varying clinical experience were involved with SIJ injections in this cohort, a factor leading to variability in the results. Our findings may not be generalizable to non-academic practices. Fluoroscopy times are an imperfect proxy for actual radiation dose. Another study is needed in order to demonstrate the effect of BMI on effective radiation exposure.

Given the technical difficulty of SIJ capsule entry [21], arthrograms were not possible in all patients. This is demonstrated by the data presented based on fluoroscopic image review performed by the blinded independent observer in the present study, where only 50% of consecutive injections were categorized as “definite” arthrograms, and only 85% were considered “definite or possible arthrograms” (though notably only based on A/P or slightly oblique imaging without a lateral view). The maximum reasonable effort to achieve an arthrogram was put forth, as described in the Methods section. However, patient reported pain during the procedure, increased fluoroscopy time/dose, and extended procedure time limit the ability to obtain true SIJ entry confirmed by arthrogram in every case. Indeed, this highlights the point that the practitioner must carefully weigh the decision of multiple entry attempts against the potentially elevated risk of vasovagal reaction, increased radiation exposure to the patient and staff, as well as the direct and indirect costs of increased procedure time. The recommended number of SIJ entry attempts is not clear in the literature, though one guideline has suggested that three attempts is reasonable [21], which is consistent with the practice of the sites included in this study. We suspect that the technical difficulty of obtaining an arthrogram has a substantial impact on the fluoroscopy times of SI joint injections. While not feasible to systematically review the fluoroscopy images from all of the patients in the current data set, given the retrospective nature of this study, this certainly highlights a need for future related investigation.

Due to missing data, a common problem with retrospective studies of any size, 20% of SIJ injections were not included in our fluoroscopy time analysis due to either lack of fluoroscopy time data or BMI data, but we do not feel this small number affects our results or conclusions. Given the nature of this study, and the data collected from three large practices, selection bias is unlikely.

**Conclusions**

The findings of this study indicate that fluoroscopy time during sacroiliac joint injections is not increased in patients who are overweight or obese, regardless of whether a first-time sacroiliac joint injection was performed, bilateral injections were performed, a trainee was involved, or a new trainee was involved.

**References**


