RESEARCH ARTICLE

The Influence of Body Mass Index on Radiation Dose and Exposure Time in Fluoroscopic Guided Hip Injections - A Comparative Analysis of Two Approaches

Sujith Sidharthan, MBBS, MS (Orth), DNB (Orth), FRCS (Tr and Orth); Chandrashekara Maliyappa, MBBS, D Orth, DNB (Orth), FEBOT, FRCS (Tr and Orth); Hans Bhinda, BSc (Hons), MBBS (Lond), FRCS (Eng), FRCS (Tr and Orth)

Research performed at Department of Trauma and Orthopedics, Southend University Hospital, Mid and South Essex NHS Foundation Trust, UK

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Abstract

Objectives: Intra-articular hip injections (IHI) are routinely performed for both diagnostic and therapeutic purposes. The procedure can be performed via either an anterior or a lateral approach with fluoroscopic guidance being widely practised. There is a risk of radiation exposure associated with fluoroscopy assisted IHI. This may be influenced either by the surgical approach or the patient's body mass index (BMI) or both. This study was undertaken to compare the relationships of the respective approaches to BMI, fluoroscopic exposure time (FET) and radiation dose (RD).

Methods: A retrospective study was conducted comprising 74 patients who underwent IHI with 37 patients in each group (anterior and lateral). Patients were assessed pre-operatively and post operatively for any complications. The intra-operative radiation dose, fluoroscopic exposure time and BMI data were collected and analyzed.

Results: The mean age of the patients in anterior and lateral groups was 61.18±14.08 and 67.21±14.39 years respectively. No complications were noted in either group. However, there was a significant increase in FET (P=0.002) and RD (P<0.001) in patients with BMI ≥ 30. In the lateral group, this trend was markedly noted with increase in FET (P<0.001) and RD (P<0.001) in patients with BMI ≥ 30. On the other hand, in the anterior group there was no statistically significant increase in FET (P=0.155) and only a moderate increase in RD (P=0.020) in patients with BMI ≥ 30.

Conclusion: Both anterior and lateral approaches to fluoroscopic guided IHI are equally safe in terms of complications involved. There is statistically significant increase in both radiation dose and fluoroscopic exposure time in patients with BMI ≥ 30. This is more pronounced in lateral approach. The anterior approach is most effective in reducing both radiation dose and fluoroscopic exposure time, more so in patients with BMI of 30 and above.

Level of evidence: III

Keywords: Body mass index, Fluoroscopy, Hip, Injections, Retrospective studies

Introduction

Intra articular hip injection (IHI) is a commonly performed procedure both for diagnostic and therapeutic purposes. Various techniques have been described for hip injections, which includes anatomical landmark technique, arthroscopic portal technique, ultrasound-guided technique and fluoroscopy guided techniques.[1-6] Although anatomical landmark techniques appear to be more cost effective, it has its own limitations.

Corresponding Author: Sujith Sidharthan, Department of Trauma and Orthopaedic Southend University Hospital, Mid and South Essex NHS Foundation Trust Prittlewell Chase, Westcliff-on-Sea, and Essex, SS0 0RY, United Kingdom

Email: sujsidh@doctors.org.uk

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Accurate palpation and precise outlining of both the anterior superior iliac spine (ASIS) and greater trochanter tip are required. The safety and efficacy of the intra-articular hip injections cannot be ensured using anatomical landmarks.[2] In addition, this technique may be unreliable in the presence of anatomical variants including femoral head-neck deformities such as coxa vara or a high-riding greater trochanter which make the surface anatomy unpredictable.[3] Evaluation of the surface anatomy and anatomical landmarks is an even greater challenge in patients with a high body mass index (BMI). Therefore, accurate needle placement by anatomical means alone cannot be guaranteed, especially in obese patients without imaging.[4]

Ultrasound-guided hip injections are equally as effective as fluoroscopy-assisted injections.[5,6] However, the performance of ultrasound-guided hip injections can be limited by body habitus and is operator-dependent.[7] The fluoroscopy-assisted injections are performed either by an anterior or a lateral approach. Nevertheless, there have been concerns about complications and radiation exposure with these techniques. Wixson et al. in a retrospective comparison study of the anterior-oblique and lateral approach to hip injections, found no difference in complication rates between the groups.[8] Although lateral injections had a higher fluoroscopic dose and exposure time than the anterior approach, this was not statistically significant.[8] However, no comparisons were made of their relationships with BMI of patients. A few studies have compared fluoroscopic dose and time with BMI of patients, using a single technique.[9,10]

Therefore, this study was conducted to compare fluoroscopic exposure time, radiation dose and BMI when fluoroscopy guided anterior and lateral hip injections are performed.

Materials and Methods

This is a retrospective comparative study conducted at a district general hospital between December 2018-2020. The list of patients by their hospital numbers, who had hip injections carried out during the above period, was obtained from the theatre IT system in a chronological order. They were then segregated into two groups based on the approach used. Fluoroscopic exposure time (FET) and radiation dose (RD) are routinely recorded in the image intensifier machine and uploaded on to hospitals PACs system while the BMI are recorded on all the admissions in the patient notes. The data were retrieved from hospital patient electronic records. The patients who had a clearly documented fluoroscopy exposure time (FET), radiation dose (RD) and BMI were included in the study. Those who did not meet the above criteria were excluded from the study. Thirty-seven consecutive patients were allocated to each group who met the above criteria giving us a total of seventy-four fluoroscopic guided hip injections for the study. All procedures were done as day cases. Most patients had local anaesthesia with sedation. They were discharged on the same day and followed up in clinics at 6 to 12 weeks.

Anterior approach: The needle is aligned parallel to the groin crease anteriorly with the needle tip a few millimetres medial to the lateral head-neck junction, under fluoroscopic guidance. This is the target, which is then marked on the skin. The needle entry point is approximately 2.5cm supero-lateral to the target. The needle is inserted posteriorly in an infero-medial direction to meet the target. The intra-articular needle position is confirmed with a positive arthrogram [Figure 1] and the joint is injected with a mixture of steroid and local anaesthetic.

Figure 1. Hip arthrogram – Anterior approach

Lateral approach: The needle entry point is just superior to the tip of the greater trochanter laterally. The needle is angulated 10 degrees anteriorly, aimed at the lateral femoral head-neck junction and inserted until bony resistance is met by the needle tip under fluoroscopic guidance. The intra-articular position of the needle is confirmed with a positive arthrogram [Figure 2] and the joint is injected with a mixture of steroid and local anaesthetic.

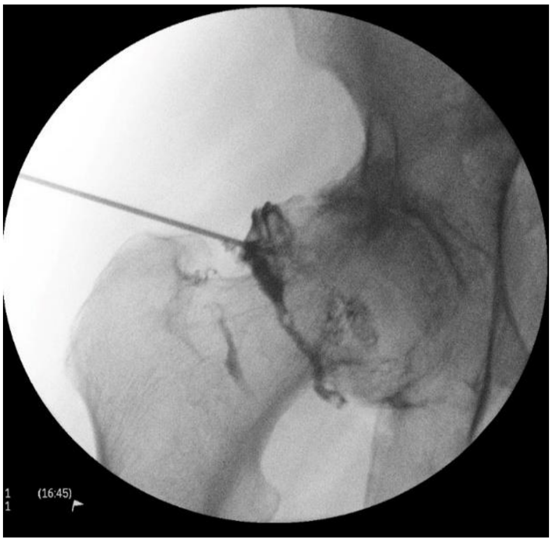

Figure 2. Hip arthrogram – Lateral approach

Statistical Analysis

The Statistical software namely SPSS 22.0, and R environment ver.3.2.2 were used for the analysis of the data. Microsoft word and Excel have been used to generate graphs and tables. Descriptive and inferential statistical analysis was carried out in the present study. Results on continuous measurements are presented on Mean ± SD (Min-Max) and results on categorical measurements are presented in number (%). Significance is assessed at 5% level of significance.

Significant figures:

+ Suggestive significance (P value: 0.05<P<0.10)

* Moderately significant (P value: 0.01<P≤0.05)

** Strongly significant (P value: P≤0.01)

The following assumptions on data were made; dependent variables should be normally distributed, samples drawn from the population should be random and cases of the samples should be independent. Student t test (two tailed, independent) was used to find the significance of study parameters on continuous scale between two groups (inter group analysis) on metric parameters. Levene's test was performed to assess the homogeneity of variance. A t-test was used to compare the means of two groups. Chi-square/ Fisher Exact test was used to find the significance of study parameters on categorical scale between two or more groups in non-parametric setting for qualitative data analysis. Fisher Exact test was used when cell samples were very small.

Results

General characteristics

There were 74 patients, 37 in each group (anterior and lateral) with a mean age of 61.18±14.08 and 67.21±14.39 years respectively. The combined mean age of both groups was 64.20±14.46 years and the patients were age matched. There were 45 female and 29 male patients combined, with 29 (39.2%) left and 45 (60.8%) right sided hip injections. The indications for hip injection include primary osteoarthritis in 64 (86.5%), hip pain 6 (8.1%), and labral tear 4 (5.4%) patients. There was no statistically significant difference between the BMI of patients in the anterior and lateral groups. They had a mean BMI of 29.63±5.07 and 28.86±6.11 respectively (*P =0.558*). Most injections were done by registrar grade surgeons 71(95.9%) and the remainder[3] by junior doctors or surgical care practitioners under supervision. There were no complications in either groups. There was no difference in the mean fluoroscopic exposure time (*P=0.596*) or the mean radiation dose (*P=0.962*) between the groups [Table 1, 2].

Table 1. Fluoroscopic exposure time (seconds) P=0.596, Not Significant, Student t Test

FET (sec)	Anterior group	Lateral group	Total
Mean ± SD	0:05±0:04	0:04±0:02	0:05±0:03

Table 2. Radiation dose (mGy.m2) P=0.962, Not Significant, Student t Test

RD (mGy.m2)	Anterior group	Lateral group	Total
Mean ± SD	0.010±0.01	0.010±0.008	0.010±0.009

Relationship to BMI

There were 43 patients (19 anterior and 24 lateral) with BMI < 30 and 31 patients (18 anterior and 13 lateral) with BMI ≥ 30 [Table 3].

Table 3. BMI distribution in the two groups studied P=0.558, Not Significant, Student t Test

BMI (kg/m²)	Anterior group	Lateral group	Total
<30	19(51.4%)	24(64.9%)	43(58.1%)
≥30	18(48.6%)	13(35.1%)	31(41.9%)
Total	37(100%)	37(100%)	74(100%)
Mean ± SD	29.63±5.07	28.86±6.11	29.95±5.59

Categorising patients based on BMI, the fluoroscopic exposure time (FET) and the radiation dose increased in a statistically significant manner in patients with BMI ≥ 30 [Table 4].

Table 4. Comparison of fluoroscopic exposure time (sec) and radiation dose (mGy.m2) in relation to BMI studied (All cases)

Variables	BMI (kg/m²)		Total	P Value
	<30	≥30		
FET (sec)	0:04±0:018	0:065±0:045	0:05±0:03 (0:042-0:058)	0.002**
RD (mGy.m2)	0.006±0.004	0.015±0.011	0.010±0.009 (0.008-0.0126)	<0.001**

We explored this further with the approaches. In the anterior approach there was no statistically significant increase in FET, but a moderately significant increase in radiation dose was noted in patients with BMI ≥ 30 [Table 5].

Table 5. Comparison of fluoroscopic exposure time (sec) and radiation dose (mGy.m2) in relation to BMI studied (ANTERIOR GROUP)

Variables	BMI (kg/m²)		Total	P Value
	<30	≥30		
FET (sec)	0:043±0:022	0:062±0:054	0:05±0:04 (0:038-0:066)	0.155
RD (mGy.m2)	0.006±0.003	0.014±0.012	0.010±0.010 (0.007-0.013)	0.020*

However, in the lateral group there was a significant increase in both the FET and RD in patients with BMI ≥ 30 [Table 6].

Table 6. Comparison of fluoroscopic exposure time (sec) and radiation dose (mGy.m2) in relation to BMI studied (LATERAL GROUP)

Variables	BMI (kg/m²) <30	BMI (kg/m²) ≥30	Total	P Value
FET (sec)	0:037±0:014	0:069±0:032	0:048±0:026 (0:039-0:057)	<0.001**
RD (mGy.m2)	0.006±0.004	0.017±0.010	0.010±0.008 (0.0076-0.0134)	<0.001**

Discussion

Hip injections are performed both as a diagnostic and a therapeutic procedure. Correct intra-articular needle placement is necessary to achieve the intended efficacy and benefits of the procedure. This can be facilitated using fluoroscopic assistance with a confirmatory arthrogram to ensure accurate placement of the needle and delivery of the injection into the hip joint space.

Most patients in our study had local anaesthesia with sedation resulting in good pain relief and patient compliance during procedure. In most of the previous studies using different techniques, either local anaesthesia or sedation were used in isolation. [1,3,4,6,10] Most procedures in our study were done by multiple registrar grade surgeons demonstrating the possibility of producing similar results even with varying levels of surgeon experience. The patient demographics of both the groups in our study were matched in terms of age, sex and BMI. There were no complications in either group. Similar results were reported by Wixson et al. in their study with no immediate complications in either anterior or lateral groups.[8]

Ionizing radiation can cause injury at a molecular level, resulting in cell injury and death that can lead to radiation burns, as well as structural changes in DNA, which increases the risk of cataract and various cancers. The most reasonable assumption is that the cancer risks from low doses of x-rays or gamma rays decrease linearly with decreasing dose.[11] Therefore, it is very important to reduce the radiation dose both to patients, theatre staff and surgeons.

Cushing et al. demonstrated that increasing BMI led to elevated radiation dose during fluoroscopically guided intra-articular hip injections, but the approach used was not specified.[9] McCormick et al. in a multi-centre cohort study of 559 patients concluded that fluoroscopy times during IHI increase with higher BMI categories in a statistically significant manner.[10] However, the radiation dose was not included in this study. In a comparative study by Wixson et al. the lateral approach group was found to have a higher median radiation dose (P=0.7) and longer median exposure time (P=0.3) than those undergoing the anterior approach.[8] The study did not include patient's BMI.

In our study, there was no statistically significant difference in the mean fluoroscopic exposure time or the mean radiation dose between the anterior and lateral groups [Table 1 and 2]. However, when we used BMI to categorise the patients, significant differences were noted. In patients with BMI ≥ 30, the FET and RD increased in a statistically significant manner [Table 3]. When BMI was factored into the individual approaches, in the anterior group, there was no statistically significant increase in FET, although a moderately significant increase in RD was noted in patients with BMI ≥ 30. On the contrary, in the lateral group, there was a statistically significant increase in both the FET and RD in patients with BMI ≥ 30. We think this could be due to the difficulty in palpating the bony landmarks with increasing BMI. As the BMI increases, gaging the depth at which the entry of the needle is made laterally on the skin surface in the lateral approach becomes increasingly difficult and this cannot be guided by the antero-posterior imaging leading to more attempts at needle placement. While in an anterior approach, the anteroposterior imaging still guides the vertical descent of the needle to the target on the hip.

The strength of our study is that it is a direct comparison of anterior versus lateral approaches with radiation dose, fluoroscopic exposure time and BMI. Limitations of our study include its retrospective nature and a small sample size. A prospective randomised control study with a larger number of patients would be a useful avenue for further study.

Conclusion

Both anterior and lateral approaches to fluoroscopic guided IHI are equally safe in terms of complications involved. There is statistically significant increase in both radiation dose and fluoroscopic exposure time in patients with BMI ≥ 30. This is more pronounced in lateral approach. The anterior approach is most effective in reducing both radiation dose and fluoroscopic exposure time, more so in patients with BMI of 30 and above.

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Sujith Sidharthan MBBS, MS (Orth), DNB (Orth), FRCS (Tr and Orth) [1]
Chandrashekara Maliyappa MBBS, D Orth, DNB (Orth), FEBOT, FRCS (Tr and Orth) [1]
Hans Bhinda BSc (Hons), MBBS (Lond), FRCS (Eng), FRCS (Tr and Orth) [1]

1 Department of Trauma and Orthopaedics, Southend University Hospital, Mid and South Essex NHS Foundation Trust, Prittlewell Chase, Westcliff-on-Sea, Essex, SS0 0RY, United Kingdom

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