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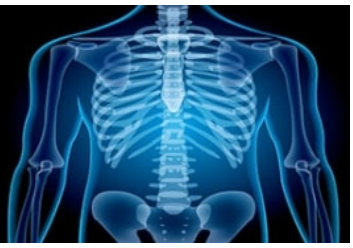

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Harir Fayeq Saadi
Department of Radiodiagnosis, Faculty of Medicine, Benha University, Benha, Egypt

Hisham El Sayed El Sheikh
Department of Radiodiagnosis, Faculty of Medicine, Benha University, Benha, Egypt

Mohamed Awaad Tawfik
Department of Radiodiagnosis, Faculty of Medicine, Benha University, Benha, Egypt

Corresponding Author:
Harir Fayeq Saadi
Department of Radiodiagnosis, Faculty of Medicine, Benha University, Benha, Egypt

Value of 18F-FDG PET/CT in guiding management of facet joint arthropathy

Harir Fayeq Saadi, Hisham El Sayed El Sheikh and Mohamed Awaad Tawfik

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Abstract
Objectives: This study aims to evaluate the diagnostic utility of 18F-fluorodeoxyglucose positron emission tomography/computed tomography (18F-FDG PET/CT) in identifying active disease sites in facet joints in patients with chronic neck and back pain.
Methods: A cross-sectional study was conducted on 70 patients presenting with chronic neck and back pain. Patients underwent clinical evaluation, laboratory testing, and imaging assessments, including PET/CT and contrast-enhanced CT. Diagnostic performance metrics such as sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were compared between PET/CT and CT.
Results: PET/CT identified active facet joint inflammation in 41.4% of 70 patients, while CT detected degenerative changes in 57.1%. PET/CT demonstrated significantly higher sensitivity (86.7% vs. 42.5%), specificity (92.5% vs. 60.0%), accuracy (90.0% vs. 50.0%), PPV (89.7% vs. 58.6%), and NPV (90.2% vs. 43.9%) compared to CT (p<0.001). Cervical facets with abnormal FDG activity were predominantly unilateral (76.9%), while lumbar facets were largely bilateral (81.3%).
Conclusion: 18F-FDG PET/CT offers superior diagnostic accuracy compared to CT in detecting active facet joint pathology, particularly when conventional imaging is inconclusive. This modality may guide targeted treatment in facet arthropathy.

Keywords: 18F-FDG PET/CT, facet joint arthropathy, neck pain, back pain

Introduction

Low back pain (LBP) is a common and disabling condition that affects individuals of all ages, significantly lowering their quality of life. However, in many cases, LBP goes unrecognized and is addressed only when it interferes with movement. Mechanical conditions, such as the complex structure consisting of two lumbar facet joints (LFJs) and one intervertebral disc, are among the leading causes of LBP. Facetogenic chronic LBP, also referred to as LFJ syndrome, affects 15% to 41% of individuals with LBP [1].

Facet joint arthropathy of the spine, also known as "facet syndrome," is a prevalent source of back and neck pain. Despite clinical overlap with other spinal disorders, the point prevalence of facet joint pain has been estimated to be approximately 45%-55% in patients with neck pain, 40%-50% in those with upper back pain, and 10%-15% in those with lower back pain [2].

Fluorine-18 fluorodeoxyglucose positron emission tomography/computed tomography (18F-FDG PET/CT) is widely used in cancer therapy. Additionally, 18F-FDG is valuable for identifying infections and inflammatory processes [3]. Moreover, PET/CT has shown potential in identifying and assessing bone defects in young adults and teenagers experiencing back pain [4].

18F-FDG PET/CT can detect diseased joints by highlighting inflammatory peripheral cells and fibroblasts based on glucose metabolism [5]. A strong relationship has been reported between the degree of FDG uptake and the extent of degenerative changes observed on CT [6].

In animal studies, FDG accumulation in arthritis reflects pannus expansion and inflammatory reactions mediated by inflammatory cytokines. This finding suggests that FDG PET is useful for assessing the inflammatory activity of arthritis and/or the response to therapy [7]. This biological process may also explain the increased FDG uptake observed in osteoarthritis (OA), which correlates with the disease's progression rate [4].

Therefore, this study aims to investigate the potential role of 18F-FDG PET/CT imaging in precisely pinpointing the sites of active disease in the facet joints.

Patients and Method

Study design and population

This cross-sectional study included 70 patients with neck and back pain who were referred to the Radiology Department at Benha University Hospitals and other centres from 1st of January 2024 to 30th of July 2024. The ethical standards stated by the Ethical Committee of Benha University Hospital were followed. Informed consent was obtained from all participants.

Eligibility criteria:

Inclusion criteria encompassed patients aged 18 years or older, of both sexes. Patients were required to have available clinical data and, when applicable, magnetic resonance imaging (MRI) reports of the spine.

Exclusion criteria were patients with a history of intervertebral disc-related pain or neurological or radiological findings indicative of such pain, as well as those with malignant or traumatic spinal lesions. Patients unable to tolerate PET/CT imaging, pregnant women, and individuals with significant comorbidities or medical conditions that could interfere with the interpretation of 18F-FDG PET/CT results or pose risks during the procedure were also excluded. Additionally, patients who had previously received treatment for facet joint arthropathy, such as facet joint injections or surgical interventions, and those with a history of allergy or hypersensitivity to the components of the imaging agents used in PET/CT were not eligible for the study.

Assessments

All patients underwent a comprehensive evaluation, including detailed history taking and physical examination by the primary investigator. Laboratory tests. Clinical evaluation assessed joint tenderness, range of motion, and functional impairment, utilizing the Visual Analog Scale (VAS) to measure pain intensity on a 0-10 scale and the Oswestry Disability Index (ODI) to evaluate functional disability, with higher scores indicating greater impairment [8, 9]. Conventional radiography or MRI was performed alongside 18F-FDG PET/CT to provide a comprehensive assessment of facet joint arthropathy.

PET/CT Imaging Protocol

All participants underwent PET/CT and contrast-enhanced CT imaging using a 128-slice hybrid scanner (Biograph mCT 128, Siemens). Patients fasted for six hours, stayed hydrated with water, and avoided strenuous activity for 24 hours before the scan. Upon arrival, height, weight, and blood glucose levels (<11 mmol/L required) were measured before FDG (4.3 MBq/kg) was injected via a 20-gauge cannula, followed by a 20 mL saline flush. Patients rested in a dimly lit room for 60 minutes post-injection, consuming 1 liter of water to reduce urinary bladder activity. Imaging included a low-dose CT for attenuation correction and a 3D PET scan with 2-minute overlapping bed positions. Contrast CT was performed using Ultravist® 370 (4 mL/s) with images reconstructed in ultra-high definition (PSF and TOF) and 1 mm slice thickness.

Outcomes: The primary outcome measure was the accuracy of 18F-FDG PET/CT in identifying active inflammatory facet joints compared to CT. The secondary outcomes of this study included pain intensity, functional disability, patient satisfaction and treatment decision impact.

Statistical analysis

Data were analyzed using statistical package for the social sciences version 23.0 (SPSS Inc., Chicago, IL, USA). Quantitative data were expressed as mean±standard deviation and ranges, while qualitative data were presented as numbers and percentages. The Chi-square test or Fisher's exact test (when expected counts were <5) was used for group comparisons. Diagnostic performance was evaluated using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy. Statistical significance was set at a p-value <0.05. Confidence intervals (CI) were set at 95% with a 5% margin of error.

Results

The demographic and clinical characteristics of the study population (n=70) revealed a mean age of 50.44±15.20 years, with a slight female predominance (52.9%). The mean pain duration was 108.64±10.74 months, with acute onset reported in 57.1% of participants and bilateral pain distribution in 68.6%. PET/CT findings showed active facet joint inflammation in 41.4% of cases, while 58.6% had normal appearances. CT imaging revealed degenerative changes in 57.1% of participants, with the remaining 42.9% showing normal findings. These results underscore the chronic nature of pain in this cohort, with a high prevalence of bilateral involvement and degenerative or active inflammatory changes detected by imaging. Table 1.

The distribution of unilateral and bilateral activity differed significantly between cervical and lumbar facets. Among cervical facets with abnormal FDG activity, 76.9% showed unilateral distribution, compared to 38.5% on CT (p=0.033). Conversely, 81.3% of lumbar facets with abnormal FDG activity demonstrated bilateral involvement, while 56.3% showed bilateral activity on CT. Regarding facet appearance on CT, 69.2% of cervical facets with abnormal FDG activity appeared normal on CT, while 30.8% showed degenerative changes (p=0.041). For lumbar facets, 25.0% of those with abnormal FDG activity appeared normal on CT, whereas 75.0% displayed degenerative changes. These findings highlight the variation in FDG activity patterns and degenerative changes between cervical and lumbar facets, with significant discrepancies between PET/CT and CT findings. Table 2.

Among the 41 patients with normal FDG uptake in facet joints, significant differences were observed in CT findings between cervical and lumbar levels (p=0.021). At the cervical level, 53.8% of joints with normal FDG uptake appeared normal on CT, compared to 35.7% at the lumbar level. Mild single-level degenerative changes were observed in 30.8% of cervical joints and 10.7% of lumbar joints. Moderate multilevel degenerative changes were more prevalent at the lumbar level (32.1%) compared to the cervical level (0.0%). Marked multilevel degenerative changes were similarly observed in 15.4% of cervical joints and 21.4% of lumbar joints. These findings suggest a higher prevalence of degenerative changes in lumbar facets despite normal FDG uptake patterns. Table 3. The diagnostic performance of 18F-FDG PET/CT was significantly superior to diagnostic CT across all evaluated parameters (p<0.001). PET/CT demonstrated a higher sensitivity

(86.7% vs. 42.5%) and specificity (92.5% vs. 60.0%) compared to CT. The positive predictive value (PPV) and negative predictive value (NPV) were also notably higher for PET/CT (89.7% and 90.2%, respectively) than for CT (58.6% and 43.9%, respectively). Overall accuracy was significantly better for PET/CT (90.0%) compared to CT (50.0%). These results highlight the enhanced diagnostic capability of PET/CT in detecting active facet joint pathology Table 4.

Table 1: Demographic, clinical, and imaging characteristics of the study population

Demographic data	Total (n=70)
Age (year)	
Range	34-68
Mean±SD	50.44±15.20
Gender	
Male n (%)	33 (47.1%)
Female n (%)	37 (52.9%)
Duration of pain (months)	
Mean±SD	108.64±10.74
Onset of pain	
Gradual n (%)	30 (42.9%)
Acute n (%)	40 (57.1%)
Pain distribution	
Bilateral n (%)	48 (68.6%)
Unilateral n (%)	22 (31.4%)
Facet appearance on PET/CT	
Normal n (%)	41 (58.6%)
Active joints n (%)	29 (41.4%)
Facet appearance on CT	
Normal n (%)	30 (42.9%)
Degenerative n (%)	40 (57.1%)

SD: Standard deviation, PET/CT: Positron emission tomography/computed tomography, n: number.

Table 2: Comparison of cervical and lumbar facet abnormalities detected by PET/CT and CT

	Cervical facets with abnormal		Lumbar facets with abnormal		X^2	p-value
	FDG activity (n=13)	CT activity (n=13)	FDG activity (n=16)	CT activity (n=16)		
Distribution of activity						
Unilateral	10 (76.9%)	5 (38.5%)	3 (18.8%)	7 (43.8%)	6.385	0.033*
Bilateral	3 (23.1%)	8 (61.5%)	13 (81.3%)	9 (56.3%)		
Facet appearance on CT						
Normal	9 (69.2%)	11 (84.6%)	4 (25.0%)	10 (62.5%)	5.331	0.041*
Degenerative	4 (30.8%)	2 (15.4%)	12 (75.0%)	6 (37.5%)		

X^2: Chi-square test, FDG: Fluorodeoxyglucose, CT: Computed tomography, *: p-value <0.05 were considered significant.

Table 3: Findings in patients with normal fluorodeoxyglucose uptake in facet joints

Facet appearance on CT	Cervical level (n=13)		Lumbar level (n=28)		X^2	p-value
	Normal FDG (n=13)	Normal CT (n=13)	Normal FDG (n=28)	Normal CT (n=28)		
Normal	7 (53.8%)	2 (15.4%)	10 (35.7%)	5 (17.9%)	7.582	0.021*
Mild single-level degenerative changes	4 (30.8%)	6 (46.2%)	3 (10.7%)	5 (17.9%)		
Moderate multilevel degenerative changes	0 (0.0%)	3 (23.1%)	9 (32.1%)	12 (42.9%)		
Marked multilevel degenerative changes	2 (15.4%)	2 (15.4%)	6 (21.4%)	6 (21.4%)		

X^2: Chi-square test, FDG: Fluorodeoxyglucose; CT: Computed tomography, *: p-value <0.05 were considered significant.

Table 4: Diagnostic performance of 18F-FDG PET/CT compared to CT

	18F-FDG PET/CT		Diagnostic CT		p-value
True Positive	26		17		<0.001*
False Negative	4		23		
True Negative	37		18		
False Positive	3		12		
	%	95% C.I.	%	95% C.I.	
Sensitivity	86.7%	(82.3%-91.0%)	42.5%	(40.4%-44.6%)	<0.001*
Specificity	92.5%	(87.9%-97.1%)	60.0%	(57.0%-63.0%)	<0.001*
Positive predictive value	89.7%	(85.2%-94.1%)	58.6%	(55.7%-61.6%)	<0.001*
Negative predictive value	90.2%	(85.7%-94.8%)	43.9%	(41.7%-46.1%)	<0.001*
Accuracy	90.0%	(85.5%-94.5%)	50.0%	(47.5%-52.5%)	<0.001*

18F-FDG: Fluorine-18 fluorodeoxyglucose; PET/CT: Positron emission tomography/computed tomography; C.I.: Confidence interval, *: p-value <0.05 were considered significant.

Cases: Case 1: A 58-years-old female presenting with 9 months back pain. Figure 1

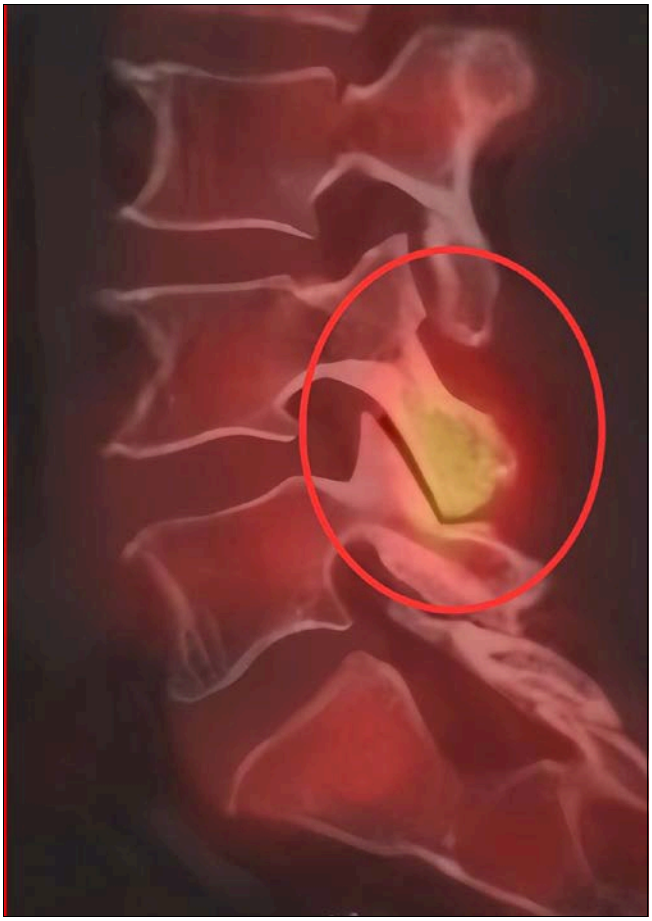

Fig 1: FDG PET/CT reveals pathological intake in L4/L5

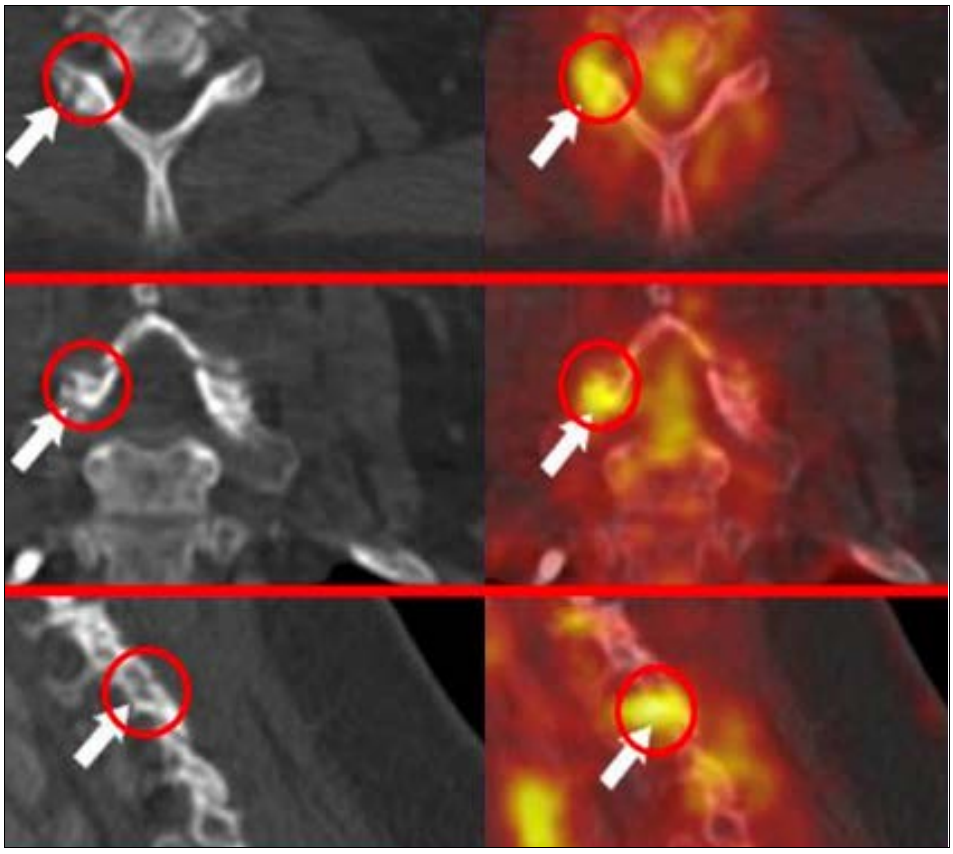

Fig 2: Rise in 18F-FDG uptake, arrows pointing to right c6/c7 facet joint without any underlying CT alterations

Case 2: A 64-years-old male presenting with 2 years history of severe neck pain. Figure 2

Discussion

Facet joint disorders, including degenerative conditions, infections, and trauma, are common causes of spinal pain but are challenging to diagnose due to referred or radicular pain originating from the same structure. Notably, the extent of facet joint degeneration does not always correlate with pain severity [10]. Osteoarthritis is the most common cause of facet joint pain [11]. Enhanced imaging modalities for detecting painful facet joints could improve the efficacy of targeted treatments like injections. Hybrid imaging techniques, including SPECT/CT, PET/CT, and PET/MRI, offer a promising diagnostic approach by combining anatomical and functional data (12). Additionally, increased pressure on facet joints causes physiological changes in the underlying bone that precede the morphological alterations visible on radiographs [13].

This study aims to investigate the role of 18F-FDG PET/CT imaging in accurately identifying active disease sites in facet joints. Currently, limited research explores the significance of 18F-FDG PET/CT in diagnosing facet joint arthropathy.

The study involved patients experiencing chronic neck and back pain, with a slightly higher proportion of females than males. Symptoms were predominantly bilateral, and pain onset varied between gradual and acute. PET/CT scans showed active joint involvement in some patients, while others had normal joints. CT findings highlighted a mix of degenerative and normal joint conditions among the participants.

Some authors demonstrated the utility of PET/CT in identifying active disease in facet joints, reporting bilaterally elevated FDG uptake in five patients, with two showing normal CT findings, two exhibiting mild degenerative changes, and one displaying moderate multilevel degeneration. More recently, some investigators studied 129 patients, reporting a similar demographic distribution with 46.5% males and 53.5% females, mean age 52±16 years, and bilateral symptoms in 69% of cases [14, 15].

A study investigated the use of 18F-Sodium Fluoride PET/CT in lumbar facet joints, reporting a mean patient age of 71±7 years with a male predominance (13). Another study evaluated neck pain using 18F-NaF PET/CT and found it clinically beneficial in 84.5% of cases, although high background vertebral uptake limited its utility in 15.5% [16].

In this study, 18F-FDG PET/CT demonstrated significantly higher sensitivity (86.7%), specificity (92.5%), accuracy (90.0%), positive predictive value (PPV: 89.7%), and negative predictive value (NPV: 90.2%) compared to CT, which showed sensitivity (42.5%), specificity (60.0%), accuracy (50.0%), PPV (58.6%), and NPV (43.9%) ($p<0.001$). These findings align with a recent study, which also reported superior diagnostic performance for 18F-FDG PET/CT over CT [15].

A study established a significant correlation between inflammatory cell activity and FDG uptake [17]. However, other studies highlighted the nonspecific nature of CT-detected degenerative changes, which are often unrelated to pain generation [18, 19]. Similarly, another study found no significant correlation between CT-assessed facet joint arthropathy and clinical outcomes in patients undergoing facet joint blocks [20].

A study noted moderate interobserver agreement (0.54) for facet arthropathy in lumbar spine MR imaging, suggesting that conventional MRI and CT can detect arthropathy but cannot reliably identify pain-generating joints [21]. Another study evaluated 67 patients with suspected facetogenic or discogenic pain using 18F-FDG PET/CT, finding abnormal tracer uptake in 83.6% of cases, with 88% sensitivity among patients without prior lumbar surgery [22]. However, their broader focus may have influenced sensitivity estimates specific to facet joints.

This study's limitations include a small sample size, which may affect generalizability, and the absence of histopathological confirmation of active facet joint disease. The focus on chronic neck and back pain may not reflect the diagnostic utility of 18F-FDG PET/CT in acute cases. Additionally, variability in image interpretation and the lack of cost-effectiveness analysis for PET/CT compared to other modalities were not addressed. Further research with larger, diverse cohorts is needed to validate these findings.

Conclusion

18F-FDG PET/CT is a valuable tool for managing pain caused by facet arthropathy by identifying affected joints, particularly when traditional imaging is non-specific or shows no abnormalities.

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Author's Contribution
Not available

Conflict of Interest
Not available

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