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## FULL PAPER

# A comparison of the psychological burden of PET/MRI and PET/CT scans and association to initial state anxiety and previous imaging experiences

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**Objective:** To investigate the level of psychological burden experienced by patients undergoing positron emission tomography (PET)/MRI scanning compared with PET/CT.

**Methods:** 100 adult patients referred for PET/CT and underwent PET/MRI scanning were eligible. Initial state, psychological burden of PET/CT and PET/MRI, scan satisfaction and preference were assessed using a purpose-designed questionnaire, comprising 61 five-point Likert scale questions and a three-point tick box question indicating preference between PET/CT and PET/MRI. State anxiety was assessed using the state portion of the State Trait Anxiety Inventory. Wilcoxon signed-rank tests compared psychological burden experienced by participants following PET/CT and PET/MRI scan.

**Results:** A greater level of psychological burden was experienced by patients during PET/MRI than PET/CT ( $p \leq 0.001$ , consistent with patients' preference for PET/CT over PET/MRI ( $p = 0.013$ ). There was a significant relationship between PET/CT psychological burden and

initial state ( $r = 0.386$ ,  $p \leq 0.001$ ). No significant relationship was identified between Initial state and psychological burden of PET MRI ( $r = -0.089$ ;  $p = 217$ ). There was a significant relationship between psychological burden of PET/CT and PET/MRI ( $r = 0.354$ ;  $p = 0.001$ ).

**Conclusion:** Patients' experience increased psychological burden during PET/MRI compared with PET/CT. Previous scanning experiences and patients' interactions prior to and during PET/MRI improved patient satisfaction. Interventions could be implemented to improve imaging outcome.

**Advances in knowledge:** This study provides evidence for the increased psychological burden of PET/MRI compared with PET/CT, and that people prefer the PET/CT procedure. We have shown that the patients who expressed a preference for PET/MRI demonstrated significantly lower psychological burden for that procedure than those that preferred PET/CT, which indicates that the benefit of reduced psychological burden could be facilitated by an appropriate intervention.

The combination of positron emission tomography (PET) and MRI to produce simultaneous PET/MRI is a new imaging modality. As awareness of PET/MRI in the patient population is far more limited than more established modalities, there is potential for a referral for PET/MRI to cause anxiety to patients. This anxiety has been shown to cause a negative reaction prior to standard MRI,<sup>1</sup> resulting in movement artefact during the procedure, and in some cases complete disruption and abandoning of examinations<sup>2,3</sup> because patients' anxiety results in their movement during the scan. Similarly, CT scans and PET/CT scans have been shown to cause embarrassment, discomfort and anxiety in patients, which contributes to an overall level of psychological burden.<sup>4</sup> In addition to a lack of understanding of the procedure, patients' perceptions in

relation to radiological procedures may be adversely affected by previous negative imaging experiences.<sup>5</sup> Furthermore, patients who believe themselves to have cancer but are unaware of their diagnosis may suffer greater distress during imaging procedures,<sup>6</sup> than patients who are aware of their diagnosis.

The experience of having a PET/MRI scan is unfamiliar to almost all patients. The gantry upon which patients are positioned is smaller than many standard MRI scanners as well as most PET/CT and CT scanners, which for many may precipitate fears of confinement.<sup>5</sup> This could be exacerbated by injection of radioactive ligand evoking fear of radioactivity<sup>7</sup> contributing to patient anxiety. Further factors that have been identified as affecting patient

experience may include scan time, insufficient preparation, environmental temperature,<sup>4</sup> experience of arrival at the hospital, discomfort in the waiting area, interactions with staff, pain and discomfort during the scan, symptoms of claustrophobia, noise in the scanner, injections of contrast agents (and other administered drugs), being alone in the scan room<sup>8</sup> and length of waiting time.<sup>9</sup>

In addition to anxiety directly precipitating an increase in movement during acquisition causing artefacts, it may also cause discomfort that may result in an increase in fluorine-18 fluoro-deoxyglucose (<sup>18</sup>F-FDG) uptake in muscle,<sup>10</sup> leading to reduced diagnostic quality of the images. Negative imaging experiences have also shown to affect a patient's perception of their health status.<sup>11</sup> Furthermore, a negative experience will in turn impact on future imaging investigations by increasing patients' predisposition to anxiety and worry for future scan(s), which decreases the quality of a patient's experience and also affects hospital workflow (*i.e.* extra time required to calm and reassure the patient).<sup>12</sup>

The aims of this study were to assess and compare the psychological burden on patients undergoing PET/MRI compared

with PET/CT and to suggest possible interventions to reduce anxiety when it occurs. We hypothesise that participants undergoing the PET/MRI procedure may experience a greater degree of psychological burden and this will result in a preference for the PET/CT procedure.

## METHODS AND MATERIALS

The study was performed as part of the clinical service development of the PET/MRI imaging service at The Institute of Nuclear Medicine at University College London Hospital, London, UK. Patients who had been referred for a PET/CT procedure for a variety of conditions were asked if they would volunteer to undergo PET/MRI during the same visit. Retrospective ethical approval has been granted for publication of these results.

## PARTICIPANTS

Out of the 100 patients who had volunteered to undergo PET/MRI after being referred for routine clinical PET/CT, 81 were able to complete the questionnaire (52 males, 29 females). Patients' age ranged from 18 to 80 years, mean 53.4 and standard deviation (SD) 14.99.

Indications for the referral for clinical PET/CT included: cancer, 58; epilepsy, 10; musculoskeletal, 5; cardiac, 2; dementia, 2; lung

Table 1. Summary of questionnaire (paraphrased for brevity)

Pre-scan questionnaire		Post-PET/CT scan questionnaire		Post-PET/MRI scan questionnaire	
1	Previous scan experiences X-ray, CT, MRI, PET/CT, Endoscopy/Colonoscopy, Ultrasound - 1□-5□	6	Please rate the pleasantness of: Transport to the hospital, Interaction with hospital staff, time in the waiting room, fasting before the scan 1□-5□	13	Please rate comfort when: asked to wear a gown, during uptake, when you were moved onto the scanner, when you were moved into the scanner, staying still on the scanner, holding your breath 1□-5□
2	Have you heard about PET/CT and PET/MRI scans before? Y□-N□	7	Did you feel the scan was properly explained to you? Y□-N□	14	Please rate whether you found the scan; Boring—Interesting, Warm—Cold, Uncomfortable—Comfortable, Peaceful—Noisy, Lonely, Small, Relaxing, Long/Brief 1□-5□
3	Did you receive information regarding your scan prior to your appointment? Y□-N□	8	Did you feel prepared for the scan? Y□-N□	15	Would you have another PET/CT scan? Y□-N□
4	Do you know why you're having this scan? Y□-N□	9	Please rate the pleasantness of: wearing a gown, cannula insertion, injection of tracer, buscopan	16	Would you have another PET/MRI scan? Y□-N□
5	State portion of the State Trait Anxiety Inventory	10	Please rate the staff for Friendliness, Kindness, Knowledge, question answering, safety, hygiene, efficiency, politeness and professionalism 1□-5□	17	Which scan did you prefer? PET/MRI □-PET/CT □
		11	Please rate comfort when: asked to wear a gown, during uptake, when you were moved onto the scanner, when you were moved into the scanner, staying still on the scanner, holding your breath 1□-5□	18	Was it: □ Much better, □ A little better, □ Mostly the same.
		12	Please rate whether you found the scan: Boring—Interesting, Warm—Cold, Uncomfortable—Comfortable, Peaceful—Noisy, Lonely, Small, Relaxing, Long/Brief 1□-5□	19	What was the main cause of the difference?

disease, 2; hepatic disease, 1; and vascular, 1. Tracers used were  $^{18}\text{F}$ -fluorodeoxyglucose ( $^{18}\text{F}$ -FDG), 69;  $^{18}\text{F}$ -fluorocholine, 6; and  $^{68}\text{Ga}$  Dotatate, 6.

## PROCEDURE

The questionnaire consisted of 61 five-point Likert scale questions, including the state portion of the State Trait Anxiety Inventory<sup>13</sup> (see Table 1 for a summary of the questionnaire). All patients underwent both procedures, starting with PET/CT (VCT-XT-Discovery™; GE-Healthcare, Waukesha, WI) followed by PET/MRI (Biograph mMR®; Siemens Healthcare, München, Germany).

## Statistical analysis

The data generated from the study were not normally distributed and were analysed using tests for nominal and ordinal data using SPSS® v. 22.0 (SPSS Inc., Chicago, IL). Data regarding scan preference were analysed using a binomial sign test, and composite scores for initial state, state anxiety, PET/CT and PET/MRI procedure psychological burden were analysed using the Wilcoxon signed-rank test. Relationships between variables were analysed using Spearman's rank-order correlations.

Composite scores were calculated to assess the "initial state" and psychological burden for both PET/CT and PET/MRI procedures.

Scores for each question relating to prior scanning experiences, information provided regarding the procedure, experience of coming to the hospital, waiting for the appointment, treatment by staff, cannulation and injection (questions 1–4 and 6–10) were added to form the initial state score. Question scales were devised so that lower scores would be indicative of a more positive experience.

The PET/CT psychological burden score was calculated by adding responses to questions relating to the PET/CT scan experience,<sup>11,12</sup> similarly the PET/MRI psychological burden score was calculated by adding responses to the PET/MRI scan experience.<sup>13,14</sup>

## RESULTS

Of the 100 volunteers who completed the questionnaire, 19 were excluded owing to missing data from incomplete questionnaires.

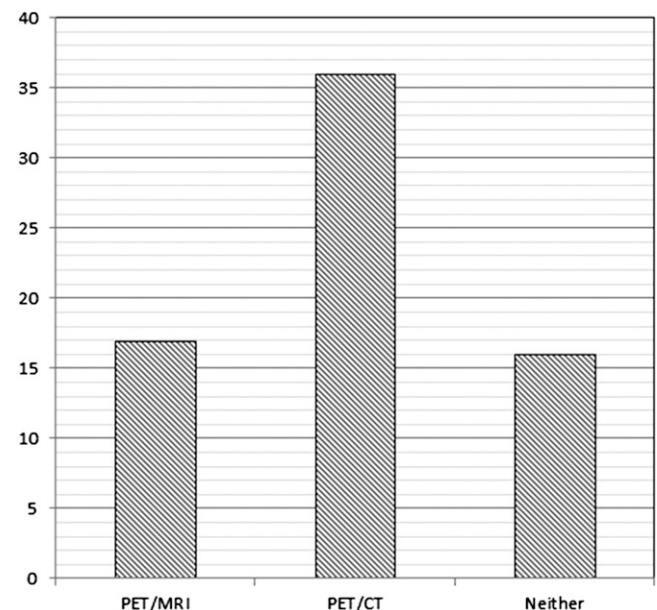
### Scan preference

69 out of 81 participants responded to the questions that required an indication of whether they preferred PET/CT, PET/MRI or neither. 36 participants responded that they preferred PET/CT, 17 preferred PET/MRI and 16 preferred neither (Figure 1). A related samples sign test reveals the group that preferred PET/CT was significantly larger than the group that preferred PET/MRI ( $p = 0.013$ ). This finding confirms our hypothesis that patients prefer PET/CT to PET/MRI.

Response to the questions "would you have another PET/CT" and "would you have another PET/MRI" on a five-point scale yielded a mean score of 1.51, SD 0.941 for PET/CT and a mean score of 1.67, SD 1.154 for PET/MRI. A Wilcoxon signed-rank test reveals that the difference between the groups was not significant ( $p = 0.072$ ).

A Wilcoxon signed-rank test was conducted to compare the degree of psychological burden experienced by participants following PET/

Figure 1. The number of patients who preferred positron emission tomography (PET)/CT vs PET/MRI procedure. y-axis = number of patients.



CT and PET/MRI scan (Figure 2). There was a significant difference between the degree of psychological burden experienced between PET/CT (mean = 29.36; SD = 8.67) and PET/MRI (mean = 35.14; SD = 8.7;  $t = -5.333$ ;  $p \leq 0.001$ ), indicating that PET/MRI causes greater psychological burden to patients than does PET/CT.

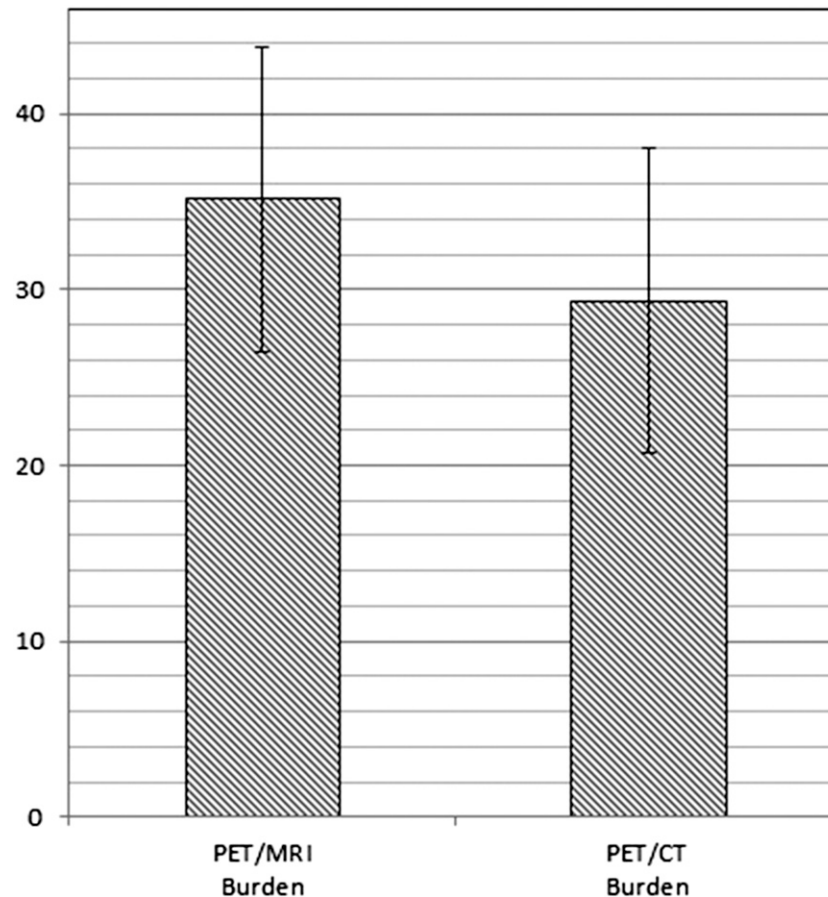
### Scan psychological burden

A Kruskal-Wallis H test showed that there was a statistically significant difference in psychological burden score between PET/CT and PET/MRI in patients who specified that they preferred PET/MRI,  $\chi^2(2) = 10.427$ ;  $p = 0.005$ , with a mean rank psychological burden score of 40.75 for patients who specified no preference, 38.85 for patients who preferred PET/CT and 21.44 for patients who preferred PET/MRI. No such significant difference exists between psychological burden for patients who preferred PET/CT over PET/MRI or expressed no preference (Figure 3). This illustrates that patients prefer the scan that causes less psychological burden and that it is possible for psychological burden to be reduced by a suitable intervention.

There was no significant relationship identified between state anxiety and psychological burden of PET MRI ( $r = 0.167$ ;  $p = 0.081$ ) or psychological burden of PET CT ( $r = 0.112$ ;  $p = 0.174$ ).

There was no significant relationship identified between initial state and psychological burden of PET MRI ( $r = -0.089$ ;  $p = 0.217$ ). There was a significant relationship between PET/CT psychological burden and initial state ( $r = 0.386$ ;  $p \leq 0.001$ ). There was a significant relationship between psychological burden of PET/CT and PET/MRI ( $r = 0.354$ ;  $p = 0.001$ ). These results show that while initial state may not have an impact on psychological burden of PET/MRI, there is a significant impact of initial state on psychological burden of PET/CT and a significant relationship between psychological burden in PET/CT and PET/

Figure 2. Amount of psychological burden experienced by patients in positron emission tomography (PET)/CT and PET/MRI procedures. *y*-axis = amount of psychological burden; error bars = standard deviation.



MRI, which means that provision of a suitable intervention to improve initial state, that psychological burden may be reduced.

## DISCUSSION

The study shows that in patients undergoing both PET/CT and PET/MRI, PET/MRI is found to be a less comfortable and more psychologically burdensome procedure with the preference for PET/CT in the majority of patients in this study. In response to the question regarding willingness to undergo further PET/CT and PET/MRI procedures, more are willing to undergo PET/CT, but this does not reach statistical significance. The experience of PET/MRI caused greater psychological burden owing to factors such as movement restriction, temperature and noise resulting from PET/MRI, leading to a preference for the PET/CT procedure, yet despite this, patients remain willing to undergo either procedure when they believe it is in their best interests.

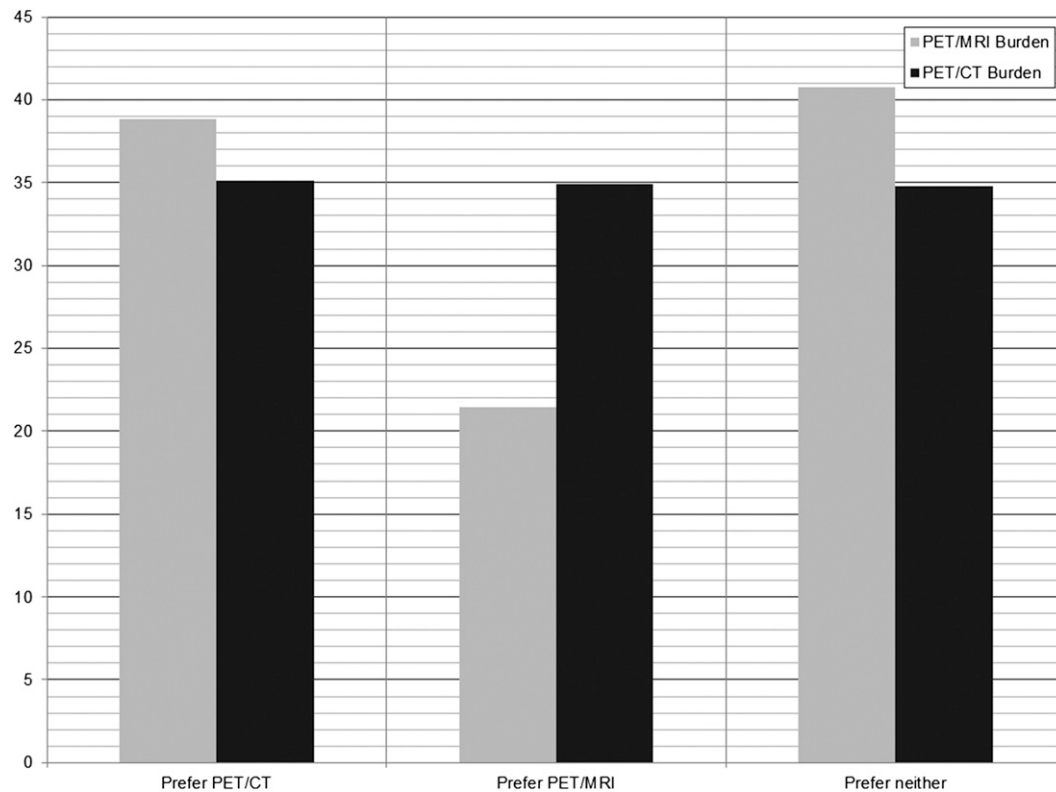
There is a significant relationship between “initial state” and the psychological burden of PET/CT, and while this relationship does not extend to PET/MRI, there is a strong relationship between the psychological burden of PET/CT and PET/MRI. This suggests that while “initial state” may be a good predictor for how patients will experience PET/CT, this is not the case in PET/MRI, this could be because patients are less knowledgeable about the procedure and none of them had experienced a PET/MRI

scan before. In terms of practice, this suggests that patients undergoing PET/MRI will likely need a higher level of support and explanation than PET/CT.

It is important to understand the reasons why patients preferred one procedure over the other. The following questions were asked: “which scan did you prefer?” and “what was the main cause of the difference?”. Of the patients who indicated PET/MRI was their preferred modality, five patients revealed that factors such as body position during the scan were an important factor. One patient specified that “arms not being positioned above the head” was preferable. Four patients pointed out nicer surroundings and buildings, while one patient highlighted improved explanation and interaction during the scan. Two comments reflected improved interactions with and a preference for the staff present. The significant difference between psychological burden of PET/MRI and PET/CT in patients who specified a preference for PET/MRI would indicate that these factors were pivotal in improving the experience for these patients.

These results show that a patient’s previous experiences of scanning and their experience and interaction prior to a scanning procedure can affect the level of psychological burden caused by subsequent scans. It is also shown that factors such as environment, explanation and staff interaction can ameliorate

Figure 3. The amount of psychological burden for each procedure split by procedure preference (y-axis = amount of psychological burden). PET, positron emission tomography.



the discomfort caused by reduced space, temperature and noise during the PET/MRI scan procedure.

Additionally, the newer improved surroundings of the PET/MRI scanner have been highlighted as a factor in improved experience in PET/MRI compared with PET/CT, a finding that is consistent with previous research on patients' satisfaction in MRI.<sup>9,14</sup>

While it is possibly the case that there is no significant relationship between initial state and PET/MRI, it is more likely that the experience of PET/MRI is more variable between patients and that seemingly small variations can make significant differences in the experience of undergoing a scan procedure. The advent of PET/MRI provides an opportunity to bring a new focus on patients' experience as well as improved structural and functional imaging results.

Potential limitations of the study include the fact that patients consistently underwent PET/CT prior to PET/MRI, which may have contributed to potential order effects. Additionally, patients underwent a range of PET/CT and PET/MRI procedures, e.g. <sup>18</sup>F-FDG for which patients need to fast, and <sup>68</sup>Gallium and <sup>18</sup>F-Choline PET/CT procedures where fasting is not necessary. However, this would not affect comparisons between psychological burden in PET/CT and PET/MRI as patients act as their own controls. The use of the Likert scale is considered controversial by some owing to its obvious limitations of arbitrary value application and subjective value setting.<sup>15</sup>

yet Likert scales have emerged as the dominant measurement tool for the quantification of attitudes in psychology.<sup>16</sup>

Future directions for our research will include an intervention to improve the "initial state" in order to reduce the psychological burden of PET/CT and PET/MRI.

In conclusion, we show that there is an increased psychological burden of PET/MRI compared with PET/CT and that the psychological burden of the PET/CT procedure increases in line with previous negative experiences immediately prior to the commencement of PET scanning procedures.

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