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Diagnostic bone imaging in patients with prostate cancer: patient experience and acceptance of NaF-PET/CT, choline-PET/CT, whole-body MRI, and bone SPECT/CT

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Abstract

Background: Patient acceptance is an important factor when implementing imaging methods in clinical practice in line with availability, diagnostic accuracy, and cost-effectiveness.

Purpose: To investigate patient experience and acceptance regarding18F-sodium fluoride (NaF) positron emission tomography/computed tomography (PET/CT), 11 C-choline-PET/CT, whole-body magnetic resonance imaging (WB-MRI), and 99mTc-hydroxymethane diphosphonate (HDP) single photon emission/computed tomography (SPECT/CT).

Material and Methods: One hundred and forty-nine patients with prostate cancer filled in a questionnaire regarding their experience of the imaging procedures they had been undergoing as part of a diagnostic accuracy study. Each patient had been undergoing a NaF-PET/CT, a WB-MRI, and either a SPECT/CT (group A) or a choline-PET/CT (group B).

Results: All four imaging methods received overall experience ratings at the favorable end of a 5-point Likert scale with the two PET/CT scans receiving marginally better average ratings (2.0) compared to SPECT/CT (2.2) and WB-MRI (2.3). The arm positioning above the head was the most uncomfortable part of the three nuclear medicine scans, whereas the acoustic noise was the most unpleasant part of the WB-MRI. The experience of staff instruction was relatively strongly correlated to the overall scanning experience of all four imaging modalities. Overall, the patients were willing to repeat the four imaging methods and NaF-PET/CT was the method most preferred in both groups.

Conclusion: Four imaging procedures were evaluated from the perspective of a selected group of prostate cancer patients. NaF-PET/CT, choline-PET/CT, WB-MRI, and bone SPECT/CT are well accepted imaging methods, and most patients prefer NaF-PET/CT.

Keywords

Patient experience, patient acceptance, whole-body MRI, PET/CT, SPECT/CT, prostate cancer

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Introduction

Modern imaging is continuously evolving and so is the ongoing debate as to what is the optimal imaging technique of bone metastases in patients with prostate cancer. Several parameters are taken into account when designating an optimal imaging technique: availability, diagnostic accuracy, therapeutic impact, cost-effectiveness, and patient acceptance.

The majority of studies of diagnostic imaging in patients with prostate cancer are diagnostic accuracy studies. However, patient acceptance is an almost

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unexplored field despite the increasing attention on patient-centered care (1,2). Therefore, we undertook a questionnaire survey of patient experience and acceptance regarding the following imaging techniques: 18F-sodium fluoride (NaF) positron emission tomography/computed tomography (PET/CT); choline-PET/CT; whole-body magnetic resonance imaging (WB-MRI); and 99mTc-hydroxymethane diphosphonate (HDP) single photon emission/computed tomography (SPECT/CT).

Material and Methods

The study protocol was approved by the regional ethics committee (approval number H-1-2014-018), and written informed consent was obtained from all participants.

Participants

One hundred and fifty-eight patients gave informed consent to participate in this questionnaire study regarding their experience of the imaging procedures they had been undergoing as part of a diagnostic accuracy study (DIMAB trial) in the period October 2014 to January 2016.

The inclusion criterion was patients with biopsy proven prostate cancer referred by the clinicians to NaF-PET/CT, which is the standard bone imaging method at our institution. Both newly diagnosed patients, patients in suspicion of relapse and patients with known bone metastases were invited to participate. In addition to the clinical NaF-PET/CT, the participants underwent two project scans: a WB-MRI and a SPECT/CT or a choline-PET/CT. The allocation to either a SPECT/CT or a choline-PET/CT and the order of the project scans were random and based on logistic circumstances like scanner and tracer availability at time of inclusion. Basic data regarding the four imaging procedures are shown in Suppl. Table 1.

Three of the participants were excluded from the questionnaire study as one of their project scans was not performed: one WB-MRI was cancelled by the participant after a bad SPECT/CT experience; one WB-MRI was cancelled because of an (unexpected) finding of an aorta stent on the scout view; and one SPECT/CT was cancelled due to technical problems with the scanner. The remaining 155 participants completed or at least initiated the imaging methods in question and were thereby eligible to fill in the questionnaire. Out of the 155 participants, 149 returned a filled in questionnaire (response rate 96%). Twenty-six out of 3278 answers were excluded from the data analyses due to missing data or incorrect tabulation (more than one ''x'' per answer). Fig. 1 shows a flow diagram illustrating the inclusion of the study participants.

The questionnaire

The questionnaire was modified on a previously published questionnaire regarding patient acceptance of imaging methods (3). The questionnaire was validated through a pilot study with six consecutive participants. The test participants filled in the questionnaire and were asked questions about their understanding of the questions by the principal investigator.

The participants received the questionnaire within a few days after completion of the last project scan. The questionnaire was sent according to the participant's choice either as a link in an e-mail or by mail with a stamped return envelope. A cover letter with a short description of each scanning technique served as a reminder of the imaging procedures. The questionnaire was anonymized, but had an identification number in order to be able to connect the answers to the participant's background information and clinical data.

The questionnaire consisted of five parts. Part 1 contained a background question regarding date of birth. Parts 2–4 had the same structure and contained questions regarding the experience with each of the scanning procedures: NaF-PET/CT (part 2), WB-MRI (part 3), and SPECT/CT (part 4a) or choline-PET/CT (part 4b). The participant had to indicate how many times he had tried the scanning technique in his lifetime and rate (on a 5-point Likert scale) his overall experience of the imaging technique and the following parts of the imaging procedure: instructions from the staff, confinement of the scanner, intravenous injection of tracer (not applied to WB-MRI), positioning of arms above the head (not applied to WB-MRI), fasting before the scan (choline-PET/CT only), intravenous injection of a contrast medium (choline-PET/CT only), noise from the scanner (WB-MRI only), and heat sensation during the scan (WB-MRI only). In addition, he had to indicate if he would be willing to repeat the imaging method in the future and was encouraged to write further comments on the scanning experience.

Finally, in the fifth part (5a/5b) of the questionnaire the participant had to indicate which of the scanning techniques, if any, he preferred and would preferably avoid given that their diagnostic performances were identical.

The questionnaire is attached in Appendix 1.

Statistical analysis

The data analyses were performed using the statistical software package R version 3.2.3 (4).

Due to the size of the study population and the data on a Likert scale, parametric tests were performed as previously described in the literature (5–7). However, it is a point for discussion whether data on a Likert scale should be analyzed as parametric or not and therefore,

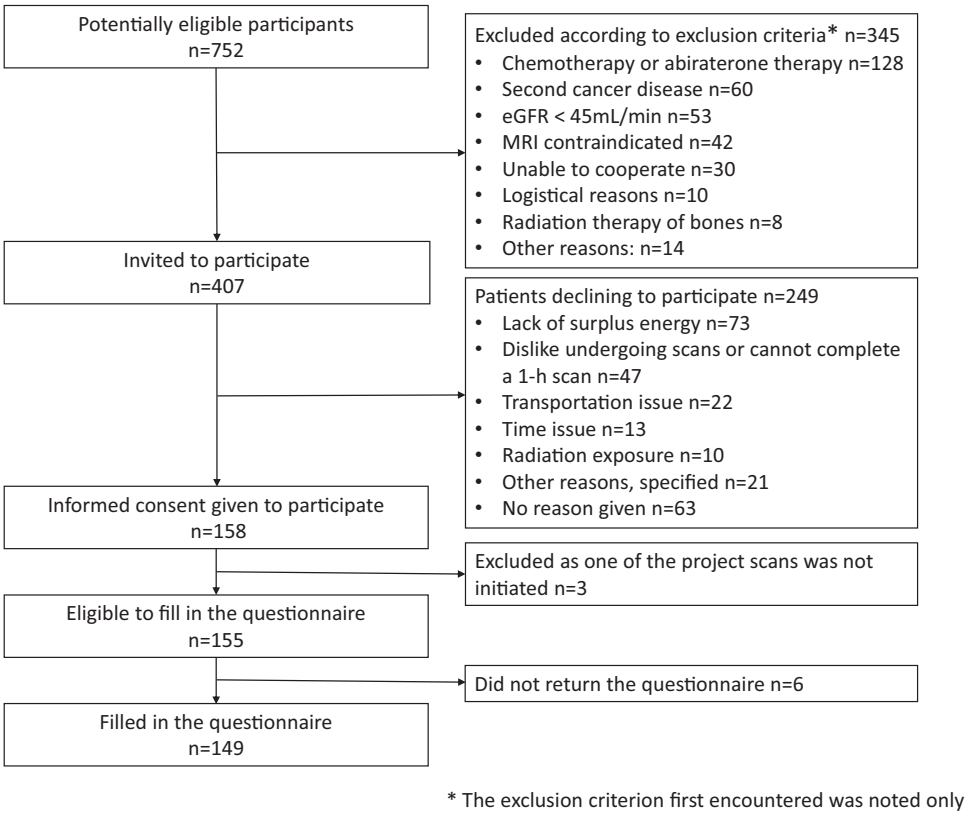

Fig. 1. Inclusion of study participants

the descriptive data are presented as frequencies and a sensitivity analysis has been calculated. A one-way ANOVA test was performed to test if there is a significant difference in experience scores between the imaging methods, and a linear regression analysis tested whether the scan type is an independent variable on the overall scanning experience. In addition, the non-parametric Kruskal–Wallis test was performed as a sensitivity analysis. Pairwise comparisons of scanning experience scores were carried out using either a paired or an unpaired t-test. Correlations were calculated using Pearson's correlation analysis. Pearson's chi-squared test assessed the participants' imaging preferences and non-preferences.

A P value < 0.05 was considered statistically significant. When appropriate, Bonferroni corrected P values were calculated.

Results

The 149 study participants had a median age of 72 years (interquartile range [IQR] = 67–78 years, age range = 49–90 years). Their median number of years with the prostate cancer diagnosis was 2.5 years (IQR = 1–5.5 years, age range = 0–17 years) and a number of the patients (21%) were known to have bone metastases at the time they were referred to NaF-PET/CT.

The average number of days between the clinical NaF-PET/CT and the project scans was 11 days for WB-MRI (range = 4–29 days), 12 days for SPECT/CT (range = 2–28 days), and 11 days for choline-PET/CT (range = 2–35 days). The average number of days from the last project scan to the completion of the electronic questionnaire (n = 66) was four days (range = 0–16 days). Corresponding response data for participants who received and returned the questionnaire by post (n = 83) are not available.

Two patients were not able to complete the WB-MRI due to claustrophobia. Previous moderate or severe adverse reactions to iodine-based contrast medium were contraindicated to participate in the study; however, two patients experienced treatment requiring adverse reactions after the choline-PET/CT (rash, swollen lip).

The patients' overall experience with NaF-PET/CT was not influenced by either the PET/CT scanner model used (mean ± SD = 1.99 ± 0.70 vs. 2.03 ± 0.45, $P = 0.71$) or the CT protocol applied (low dose CT [2.01 ± 0.54] vs. diagnostic CT with a contrast medium [1.98 ± 0.70], $P = 0.79$).

NaF-PET/CT and choline-PET/CT received similar and favorable overall experience average scores of 2.0, which are just marginally better than SPECT/CT (average score = 2.2) and WB-MRI (average score = 2.3) (Suppl. Table 2). There was a just significant difference in the overall experience scores between the four imaging techniques ($P = 0.02$) (Table 1), and after correction for age, bone disease status, and previous scanning experience, this difference was still significant ($P = 0.01$). A sensitivity analysis resulted in a similar but just non-significant P value ($P = 0.07$) (Table 1). A pairwise comparison revealed that the patients found NaF-PET/CT significantly more pleasant than WB-MRI ($P = 0.0001$) (Table 2). Previous experience of a given imaging procedure did not significantly influence the participants' overall scanning experience ratings in regard to any of the four imaging procedures ($P = 0.05$, $P = 0.16$, $P = 0.17$, $P = 0.25$). Age (<70.0 vs. > 70.0 years) had an influence on the participants' SPECT/CT experience only ($P = 0.001$), but a repeat of the test excluding those who initiated the scan with the arms positioned along the body resulted in a borderline significant P value ($P = 0.02$) which was non-significant after Bonferroni correction.

Most of the patients did not have any major issues with the space in the scanners (Suppl. Table 2). However, the acoustic noise was the most unpleasant part of the WB-MRI and in all three nuclear medicine imaging procedures, arm positioning above the head was the most uncomfortable part (Suppl. Table 2).

SPECT/CT was significantly more uncomfortable compared to NaF-PET/CT and choline-PET/CT in regard to the arm positioning ($P < 0.001$, $0 < 0.0001$) (Table 2). Patients who requested their arms to be positioned along the body as the image acquisition initiated were not included in these analyses. During the SPECT/CT, 27 patients had to change the arm positioning from above the head to along the body; in addition, 17 patients had to empty their bladder.

Table 3 depicts the results of a correlation analysis illuminating the degree of association between the patients' experience of the different procedures of each imaging modality and their overall scanning experience. A comparison of the correlation coefficients revealed that the experience of staff instruction was relatively strongly correlated to the overall scanning experience of all four imaging modalities.

Fig. 2 shows a bar chart of the imaging method preferences and non-preferences of the patients who underwent NaF-PET/CT, WB-MRI, and SPECT/CT (group A), and of those who underwent NaF-PET/CT, WB-MRI, and choline-PET/CT (group B). Most patients preferred NaF-PET/CT in both groups, whereas most patients would preferably avoid SPECT/CT in group A and WB-MRI in group B. A comparison of the participants in group A and group B revealed no difference

Table 1. Comparison of the average scanning experience ratings.

	NaF-PET/CT	WB-MRI	SPECT/CT	Choline-PET/CT	One-way ANOVA *P* value	Kruskal–Wallis test *P* value
Overall experience	2.0 ± 0.6	2.3 ± 0.9	2.2 ± 1.0	2.0 ± 0.7	0.02	0.07
The space in the scanner	1.5 ± 0.7	1.8 ± 1.0	1.7 ± 0.8	1.5 ± 0.6	0.02	0.07
Positioning arms above head*	2.4 ± 1.0	NA	3.1 ± 1.3	2.2 ± 1.0	<0.0001	<0.0001

The experience ratings are presented as mean ± standard deviation.
*Patients who initiated the scans with arms along the body are not included.

Table 2. Pairwise comparisons of the average scanning experience ratings.

	NaF vs. WB-MRI	NaF vs. SPECT/CT	NaF vs. choline	WB-MRI vs. SPECT/CT	WB-MRI vs. choline	SPECT/CT vs. choline
Overall experience	0.0001	0.22	0.78	0.32	0.02*	0.37
The space in scanner	<0.001	<0.05*	0.89	0.76	0.02*	0.10
Positioning arms above head†	NA	<0.001	0.19	NA	NA	<0.0001

Results from t-tests, paired (NaF-PET/CT vs. WB-MRI only) or unpaired.
*The *P* value is not significant after Bonferroni correction.
†Patients who initiated the scans with arms along the body are not included.
NaF, NaF-PET/CT; choline, choline PET/CT.

between the groups concerning age, reason for referral, or bone disease status (Suppl. Table 3).

Several patients added comments on their experience of the scanning techniques. Comments on the SPECT/CT (n = 26) were predominantly about the discomfort associated with positioning the arms above the head (n = 11). Participants commenting on WB-MRI (n = 42) emphasized the discomfort from the scanner noise or suggested music during the scan to reduce the noise (n = 11). Others underlined the long duration of the WB-MRI (n = 8), drew attention to the lack of time indications during the scan or suggested a visible clock in the scanner (n = 6). Comments on choline-PET/CT (n = 13) were mostly concerning the adverse events (heat sensation, metal taste) from the CT contrast medium (n = 5), whereas comments on NaF-PET/CT (n = 24) had no specific pattern.

Overall, the patients were willing to repeat all four imaging methods, particularly NaF-PET/CT, with 100% of the patients (n = 147) indicating their willingness. In comparison, 96% of the patients indicated their willingness to repeat choline-PET/CT, 94% to repeat WB-MRI, and 90% to repeat SPECT/CT.

Table 3. Correlation of parameters to the overall scanning experience.

	R (95% CI)
NaF-PET/CT	
Scanner space	0.29 (0.14–0.43)
Tracer injection	0.21 (0.06–0.37)
Arms above head*	0.21 (0.04–0.36)
Staff instruction	0.36 (0.21–0.50)
WB-MRI	
Scanner space	0.44 (0.31–0.57)
Acoustic noise	0.57 (0.46–0.67)
Heat sensation	0.26 (0.10–0.40)
Staff instruction	0.49 (0.36–0.61)
SPECT/CT	
Scanner space	0.42 (0.21–0.59)
Tracer injection	0.19 (−0.04–0.40)
Arms above head*	0.56 (0.35–0.71)
Staff instruction	0.40 (0.18–0.57)
Choline-PET/CT	
Scanner space	0.20 (−0.03–0.41)
Tracer injection	0.38 (0.17–0.56)
Contrast injection	0.50 (0.31–0.65)
Arms above head*	0.14 (−0.09–0.36)
Fasting	0.40 (0.20–0.58)
Staff instruction	0.46 (0.26–0.62)

Results from Pearson's correlation analysis.
*Patients who initiated the scans with arms along the body are not included.
CI, confidence interval; R, correlation coefficient.

Discussion

This study investigated the experience, acceptance, and preferences regarding four imaging methods in patients with prostate cancer. The main result of the study was that NaF-PET/CT, WB-MRI, SPECT/CT, and choline-PET/CT were all well-accepted imaging methods.

No previous studies have compared patient experience of PET/CT, WB-MRI, and SPECT/CT. However, Andersson et al. performed a questionnaire study on 50 prostate cancer patients' experience of NaF-PET/CT and concluded, in line with this study, that most patients felt no discomfort during NaF-PET/CT (2). In addition, Adam et al. investigated lymphoma patients' experience of WB-MRI and CT (n = 36) and found, in concordance with this study, that WB-MRI was well accepted with experience ratings at the

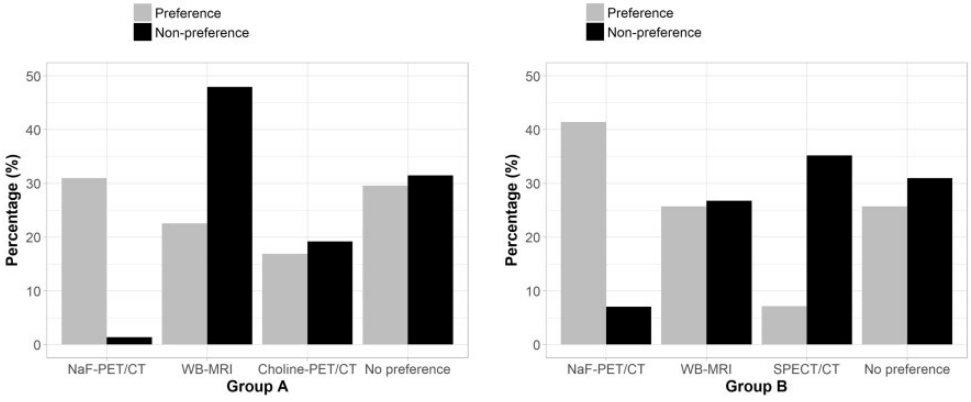

Fig. 2. Imaging methods preferences and non-preferences. In group A, there was a significant difference in the patients' preferences ($P < 0.001$) and non-preferences ($P = 0.002$). In group B there was no significant difference in the patients' preferences ($P = 0.22$), but a difference in their non-preferences ($P > 0.0001$).

favorable end of the rating scale, and moreover that whole-body MRI was experienced as a more patient-friendly technique compared to CT (1).

The overall and specific experience ratings of the two PET/CT scans are very similar, which is expectable considering their comparable scanning protocols. Only choline-PET/CT requires fasting before image acquisition, but most patients found the fasting without any discomfort. The clinicians did not consistently request the clinical NaF-PET/CT to be performed with a contrast agent, and therefore the experience of the CT contrast medium injection was investigated in connection to the choline-PET/CT only.

Body position during imaging has been described as an important factor in patient preferences of imaging methods (8). This study shows that the positioning of the arms above the head was the most uncomfortable part of both NaF-PET/CT, choline-PET/CT, and SPECT/CT. The degree of discomfort from the arm positioning was significantly higher during SPECT/CT compared to both PET/CT scans, presumably because of the approximately five times longer duration of the SPECT/CT. A large number of the SPECT/CT scans were initiated with arms positioned along the body or paused because the patients had to change their arm positioning, and the latter resulted in additional scan duration. A correct arm position is not a prerequisite to perform the nuclear medicine scans, but it optimizes the diagnostic image quality.

Several patients needed a toilet break during the SPECT/CT, and this was probably due to the prostate cancer or an age-related prostate hypertrophy leading to a not complete empty of the bladder after the per protocol pre-scanning water intake. Finally, one patient felt that the SPECT/CT experience was so uncomfortable that he decided not to undergo the other project scan.

MRI is notorious for being noisy and with little space in the scanner. This study showed that the acoustic noise was the most unpleasant part of the WB-MRI experience. Several patients commented that listening to music during the scan might reduce the discomfort from the noise. Most of the patients did not have any major issues with the space in the MRI scanner. Several patients commented on long duration of the WB-MRI scan and some patients suggested more frequent time indications or a visible clock to be able to follow the time progression of the MRI scan.

The duration of both the SPECT/CT and MRI was approximately five times longer than the PET/CT scans in this study. Improvements in scan times will likely influence the patients' scanning experiences. A reduced acquisition time of SPECT to as little as 25% has been reported not to compromise the diagnostic confidence of SPECT/CT (9). Furthermore, it has been noted that whole-body SPECT/CT is currently predominantly performed on experimental basis, and the clinicians often prefer the less time-consuming planar bone scintigraphy with a single add-on SPECT. Newer MRI scanners and computer hardware can reduce the duration of the WB-MRI scanning protocol used in this study to 50 min, and a WB-MRI protocol of 30 min has recently been proposed for detection of bone metastases in patients with prostate cancer (10).

Previous studies have indicated that the interaction between the patient and the staff has an important influence on the patient's scanning experience and preference (8,11). This study confirmed that there was a relatively strong correlation between the experience of the staff instructions and the overall scanning experience concerning all four imaging modalities investigated.

This questionnaire study was based on a large number of study participants and gave insight into an almost unexplored field. However, the study has limitations. A large number of prostate cancer patients referred to NaF-PET/CT were not eligible to participate due to the exclusion criteria applied to the diagnostic accuracy study. For example, patients with advanced cancer in chemotherapy or abiraterone therapy were excluded. Therefore, the results of this study are based on a selected group of prostate cancer patients and they have to been seen in the light of this.

The patients were invited to participate in the study after undergoing the clinical NaF-PET/CT; approximately 10% of the prostate cancer patients declined participating for the reason that they disliked undergoing scans or could not complete a 1-h scan. Thus, the experience and acceptance of the imaging techniques in this study population were probably more favorable compared to a background population. In addition, the fact that the two project scans were consistently performed after the NaF-PET/CT might have introduced an order effect. The patients indicated their imaging preferences given that the performances of the imaging methods were identical, but if future studies show that there is a difference in their diagnostic performances, this might influence the patients' preferences. Finally, the patients' perception of the radioactivity associated with the nuclear medicine scans was not investigated.

In conclusion, patient acceptance is an important factor when developing and implementing imaging methods. This study evaluated four imaging procedures from the perspective of patients with prostate cancer. NaF-PET/CT, choline-PET/CT, bone SPECT/CT, and WB-MRI are all well accepted imaging methods, and most patients indicate their preference for NaF-PET/CT.

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Declaration of Conflicting Interests

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Appendix 1

The questionnaire