Patient Experience Journal

Volume 9 | Issue 3 Article 19

2022

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Recommended Citation

Pinkster HJ, Meesters AM, IJpma FF, Taal E, Kraeima J, Ten Klooster PM. Developing a patient satisfaction measure for imaging-based patient information during clinical consultations. *Patient Experience Journal*. 2022; 9(3):136-144. doi: 10.35680/2372-0247.1668.

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Cover Page Footnote

We would like to express our gratitude to A.J. Andela and M.M. Hamminga (University Medical Center Groningen) for their support and help during the data collection stage of this study. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. This article is associated with the Quality & Clinical Excellence lens of The Beryl Institute Experience Framework (https://www.theberylinstitute.org/ExperienceFramework). You can access other resources related to this lens including additional PXJ articles here: http://bit.ly/PX_QualityClinExc

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Patient Experience Journal
Volume 9, Issue 3 – 2022, pp. 136-144

Research

Developing a patient satisfaction measure for imaging-based patient information during clinical consultations

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Abstract
Different types of medical imaging are increasingly being used to explain specific aspects of injuries to patients during consultations. However, there are no validated questionnaires available yet that specifically measure patients' satisfaction with the use of such images. The objective of this study was to develop and evaluate a patient-centred measure of satisfaction with the use of medical imaging modalities in clinical treatment. A preliminary 22-item version of the Questionnaire for Patient Satisfaction with Imaging (QPSI) was developed based on extant literature and interviews with trauma patients. Final item selection and psychometric evaluations were conducted amongst a sample of 106 hospital trauma patients who were shown medical images of their injuries. The psychometric analyses resulted in a final 13-item questionnaire comprising two subscales that measure the importance of seeing the images (9 items) and the clearness of the image (4 items). Both subscales showed adequate internal consistency ($\alpha = 0.84$ and 0.75). The subscales were weakly intercorrelated ($\rho = 0.34$) and were both significantly and independently associated with patients' global ratings of satisfaction with the use of imaging. The final two-dimensional QPSI is an innovative, reliable and valid questionnaire for measuring patients' satisfaction with imaging-based information during clinical consultations.

Keywords
Patient satisfaction, medical imaging, x-ray, MRI, CT, 3D models, 3D VSP, questionnaire, validation

Introduction

Medical imaging is frequently used by physicians for diagnostic and treatment purposes, for example, helping them to identify the location of an injury or to detect a tumour.[1] Imaging is also used to help patients better understand their own disease or injury, as well as support shared decision-making with physicians about their treatment.[2–4] To facilitate optimal information provision to patients, it is important to show them a clear image of their injury.[5] Examples of different imaging techniques are x-ray images, magnetic resonance imaging (MRI), computerised tomography (CT), and three-dimensional (3D) virtual models. X-rays have been in use for over a century and can quickly provide an image of a specific body part. The more recently developed CT and MRI images have the advantage of providing multiple segmented images, not to mention the fact that they allow for the provision of more detailed information for specific medical conditions.[2] 3D virtual models, which are generated from CT or MRI datasets, are relatively new, and have only been used in hospitals in the last two decades. Compared to 2D images, 3D models can provide more detailed information and improved visualisations.[6,7] It is also possible to interact with the 3D model (e.g. rotation, zoom), in order to both highlight specific parts of the images and display all of the information in one image instead of several segmented images.[6,8,9] However, there is a paucity of information available about patients' experiences with these 3D models.[10]

Although images are increasingly used in hospitals to inform patients during consultations, there is a relative dearth of research examining patients' satisfaction with – or preferences for – different types of imaging modalities. One of the few available studies on patients' satisfaction with imaging demonstrated that patients who saw MRI scans were more satisfied with the level of care they received than patients who saw no images, thus illustrating the importance of showing images to patients prior to their treatment.[11] Cox et al.'s study reported that showing images to patients produces a series of benefits, including improving patients' knowledge, supporting patient-clinician communication and encouraging healthy behaviour.[4] However, Gichoya et al. found that not all patients understand the different types of images that are

presented to them which may lead to an increased level of anxiety. This highlights the importance of sharing images with patients that they can understand.[12] No studies have hitherto examined at length which specific aspects of imaging-based patient information during clinical consultations enhance patients' satisfaction or understanding of their injury, nor have they considered whether various imaging modalities are appreciated differently. This is relevant, given that satisfied patients find it easier to follow medical instructions and require, on average, fewer medical visits.[13] Research has also found that higher levels of patient satisfaction are related to better adherence to, and less early dropouts from, treatment.[14] While patients' experiences have also been shown to be an important indicator of healthcare quality.[15] Moreover, information on patient satisfaction can be used to tailor treatments to the distinct needs of specific groups of patients.[16] Despite the importance of optimally tailoring treatments to patients' needs, no validated measures are currently available that specifically focus on assessing patients' satisfaction with the use of imaging during consultations. Although hospitals measure patient satisfaction with more generic questionnaires like the Consumer Assessment of Healthcare Providers and Systems (CAHPS) surveys, we are currently lacking the regulatory requirement and tools to capture specific parts of the patient journey like the diagnostic testing journey. Therefore, it is needed to develop specific questionnaires to measure patient satisfaction that can be used by hospitals to also measure more specific aspects of the quality of their health care form the patient's perspective.[17]

The aim of the current study was to develop a questionnaire to measure patients' satisfaction with different types of medical imaging (Questionnaire for Patient Satisfaction with Imaging (QPSI)). The QPSI was evaluated in a psychometric field test amongst trauma patients in order to structurally evaluate how satisfied the patients were who were informed about their injury using 2D and 3D medical images.

Methods

Phase 1: Development of QPSI

The potential items to be included in the QPSI were developed after conducting both an extensive literature review and interviews with trauma patients. The literature review suggested that the following aspects potentially contributed to patients' satisfaction with medical imaging: meeting the treatment expectations of patients,[18] the amount of information provided to patients,[19] patients' level of anxiety,[5] level of trust that patients have in the treatment,[5,10] patients' satisfaction about the treatment,[5] patients' understanding of the information provided via the image,[20,21] and how the provided information contributes towards the decision-making process.[22,23]

Additional aspects were identified after carrying out interviews with twelve trauma patients (seven male and five female patients) following consultations in which they were shown an image of their fracture. These additional aspects pertained to how images stimulate memory recall about information, how clear the provided information is to patients, showing progress in the recovery process of the injury, how seeing images contributes towards adherence to treatment and how seeing images is related to the recovery process.

A preliminary set of 22 five-point Likert-scale items were formulated based on the identified aspects. Next, the preliminary QPSI was tested for its completeness, relevance and clarity via conducting the Three-Step-Test-Interviewing (TSTI) method[24] amongst eight additional trauma patients (four males and four females) who had a consultation in which they saw an image of their fracture. Interviewing via TSTI resulted in neither new aspects nor the exclusion of aspects, thus suggesting that the items had adequate content validity. However, some items were rephrased based on the findings of TSTI, in order to improve their readability and understandability.

Phase 2: Field testing

Respondents and procedure

The preliminary 22-item version of the QPSI was field tested for its psychometric properties amongst trauma patients with fractures at the University Medical Centre Groningen in the Netherlands. Patients were selected via convenience sampling. Over a three-month period (from January to March 2020), consecutive patients that presented at the outpatient clinic of the department of trauma surgery were asked to participate in this study, and subsequently asked to complete the QPSI after the consultation with their physician. Patients were eligible if they were shown an image during the consultation with their treating physician. The specific kinds of fractures of the participating patients differed widely, ranging from a pelvic fracture to a thumb fracture. In some instances, patients even had multiple fractures. Both patients who were younger than 18 and patients who could not sufficiently read Dutch were excluded from the study. Participation in the study was voluntary and patients were informed that participating would not influence their treatment in any way. The study was reviewed and approved by the ethics committee of the faculty of behavioural, management and social sciences at the University of Twente (application number 191323). All patients provided verbal informed consent to participate in this study.

Materials

The preliminary QPSI contained six questions about demographics, one question about the imaging modality (x-rays, MRI, CT or 3D models), 22 Likert-type satisfaction items (Appendix A), one 1-10 numerical rating

scale for global satisfaction, one yes/no question about recommending the use of images, and an open text field for respondents to explain their answers in more detail or provide additional comments. The demographic questions pertained to gender, age, highest level of education, number of injuries, type of fracture and how many weeks after the injury the QPSI was filled in. The response scale for the 22 Likert-type items ranged from totally disagree (1) to totally agree (5). Four items were negatively formulated and were recoded before analysis. The 1-10 global rating scale asked patients about their general satisfaction towards the use of images, where 1 indicated 'very unsatisfied' and 10 'very satisfied'. The last question asked if the respondents would recommend the use of images in the treatment of other patients. This question could be answered with yes or no, while the respondents also had the option of explaining their answer in more detail or adding additional information should they wish to do so.

Analysis

All analyses were executed using SPSS (version 24, IBM, Chicago, IL, USA). Five stepwise analyses were performed to select the final items and assess the psychometric properties of the QPSI.

Item quality

First, an item analysis was carried out by computing the inter-item correlations and item response distributions. Pairs of items with a correlation higher than 0.7 were considered potentially redundant,[25] with the removal of one of those items being based on balancing item formulation and content coverage. Next, items were analysed for floor and ceiling effects by examining the response distributions. Given that most patient satisfaction questionnaires report highly skewed satisfaction ratings,[26] those items in which more than 80% of the respondents selected either the lowest or highest response option were ultimately deemed to be unsuitable for the questionnaire.

Structural validity

A Principal Component Analysis (PCA) was conducted to both explore the number of empirical factors underlying the remaining items and to indicate if the questionnaire should be scored as either a total scale or as separate subscales. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was used to indicate the suitability of the data for factor analysis. The KMO had to be at least 0.5 or higher to support performing a factor analysis.[27] An iterative series of PCAs with varimax rotation was performed to identify both the underlying dimensional structure of the scale and those items that best represented these factors of satisfaction.

First, a PCA parallel analysis with 100 simulated random datasets based on the permutations of the actual dataset was utilised to determine the number of factors with observed eigenvalues that exceeded the 95th percentile of the eigenvalues from the random datasets.[28,29] Next, items were iteratively removed in a series of PCAs with a fixed number of factors based on the parallel analysis until the following conditions were met for all items: items needed to have a positive factor loading of 0.40 or higher, items needed to load on one factor only with 0.40 or higher, and the difference in factor loadings for one item needed to be more than 0.10.[27,30] The items which were removed as a result of the PCAs were not used in further analyses.

Internal consistency

The internal consistency of the total scale or subscales resulting from the PCA was tested using Cronbach's alpha (α). A minimum Cronbach's α of 0.7 was considered necessary for adequate internal consistency for group-level analysis of the scale scores.[31] If this criterion was not met, it was subsequently examined if Cronbach's α could be sufficiently increased by removing additional items.

Discriminant validity

To assess the discriminant validity of any underlying factors, first Spearman's ρ intercorrelations between the mean scores of the final subscales were computed. Subscales were expected to be at most moderately intercorrelated ($\rho < 0.70$) if they were to be considered sufficiently independent factors of patients' satisfaction with imaging. Next, a multiple linear regression analysis was performed to examine whether the subscales were significantly and independently associated with the global rating scale of patients' satisfaction with imaging.

Results

Respondents

Although a total of 108 respondents agreed to participate, two respondents were ultimately excluded because they could not independently read Dutch texts, which left 106 respondents available for further analysis. Out of these respondents, 61 respondents (57.5%) were male, and 45 respondents (42.5%) were female. The age of the respondents ranged from 18–93 years old, with a mean age of 51 years (SD = 20.7). The moment at which the QPSI was completed ranged from one week after the injury up until 110 weeks after the injury, with a mean of 22 weeks after the injury (SD = 26.6). An overview of the respondents' characteristics can be found in Table 1. No individual item responses were missing.

Item quality

Item analysis indicated two pairs of items with high correlations: item 1 ("The image provided clear information about my injury") had an inter-item correlation of 0.73 with item 2 ("The image provided a lot of information about my injury"), and item 3 ("I became anxious when I first saw the image") had an inter-item correlation of 0.71 with item 15 ("I found seeing the image

Table 1. Characteristics of the respondents

Baseline characteristics	Number of respondents	Percentage of respondents
Gender		
Male	61	57.5%
Female	45	42.5%
Highest level of education		
Primary education	10	9.4%
Pre-vocational education	16	15.1%
Vocational education	35	33.0%
Higher general continued education	4	3.8%
Preparatory scientific education	1	0.9%
University of applied sciences	27	25.5%
Research university	13	12.3%
Imaging modality		
X-ray	91	85.8%
MRI	2	1.9%
CT	7	6.6%
3D model	6	5.7%
Location of the fracture		
Thorax / abdomen / pelvis	61	57.5%
Arms	28	26.4%
Legs	17	16.0%

of my injury to be confrontational"). Based on formulation and content coverage, items 2 and 15 were subsequently excluded from the questionnaire and not used during further analyses.

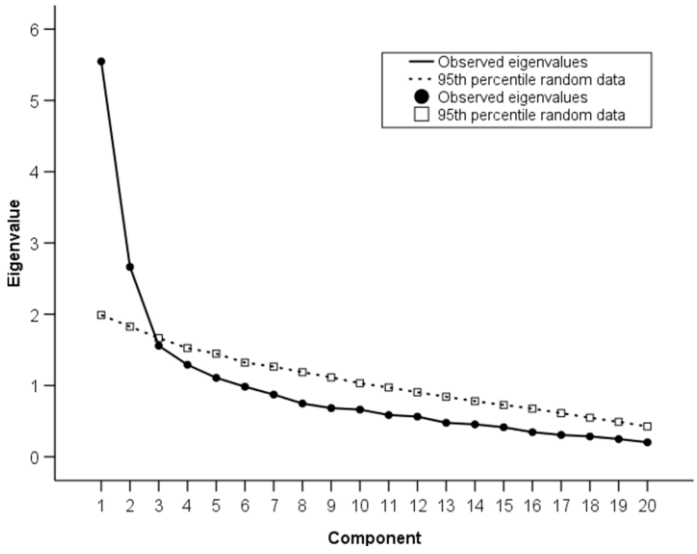
The inter-item correlations also showed that despite recoding, the four negatively formulated items had the highest number of negative correlations with the other items. These correlations ranged from -0.01 to -0.30 with six to sixteen different items. Despite these negative correlations, these items were nevertheless kept for further structural validity analysis.

Item response frequencies showed that none of the items were scored by more than 80% of the respondents on either the lowest or highest response categories. The table in Appendix B presents the response distribution for each item.

Structural validity

Five different factors with eigenvalues >1 were found in the initial PCA, with the remaining 20 items having an explained total variance of 60.84%. However, the parallel analysis (Figure 1) showed that only the eigenvalues of the first two factors were greater than the 95th percentile of the

Figure 1. Scree plot of observed eigenvalues and 95th percentiles of eigenvalues from parallel analysis (100 random datasets)



distribution of eigenvalues derived from the random data. Therefore, subsequent PCAs were executed with a fixed number of two factors.

Six items were removed during this stepwise series of PCAs. Additionally, one more item was deleted during the testing of internal consistency in the next stage. This was item 16 ("I found it difficult to see the exact location of my injury on the image"), which was removed to increase the internal consistency of its respective factor. PCA was repeated on this final set of 13 items and resulted in an acceptable and interpretable final factor structure (Table 2). The KMO value was 0.79, which indicated that the data was suitable for executing PCA. The total explained variance of the final factor solution was 49.51%. The final factor solution presented a clear factor structure with two factors, both with strong and unique loadings. The first factor comprising 9 items was labelled as 'importance of seeing images', while the second factor comprising 4 items was labelled as 'clearness of the image'.

Internal consistency

The initial factor structure resulting from the PCAs showed a high Cronbach's α value of 0.84 for factor 1 and a nearly acceptable value of 0.67 for factor 2. The final deletion of item 16 ("I found it difficult to see the exact location of my injury on the image") resulted in an acceptable Cronbach's α of 0.75 for factor 2 (with four items).

Discriminant validity

Spearman's ρ between the mean scores of both factors was 0.34, thus indicating a significant ($p < 0.001$) but weak correlation, which suggests that the two factors measure relatively independent aspects of satisfaction. Multiple linear regression analysis confirmed the discriminant validity of the two factors of patients' satisfaction, insofar as both the importance of seeing images ($\beta = 0.20$, $p = 0.034$) and clearness of the image ($\beta = 0.36$, $p < 0.001$) were independently associated with global satisfaction about imaging. However, the total explained variance in global satisfaction for both subscales was modest at 20.8%.

Discussion

This study sought to develop and evaluate a new measure of patients' satisfaction with image-based fracture education in a psychometric field study amongst trauma patients, who were educated about their injury during consultations using medical imaging. The final QPSI is a brief, reliable and valid measure of patients' satisfaction with the use of imaging during clinical consultations. The remaining items showed adequate item quality and a clear underlying factor structure with two relatively independent dimensions of satisfaction. Internal consistency was adequate for both factors, while the two subscale scores showed discriminant validity with respect to global satisfaction with the use of imaging. Overall, the QPSI appears to be a promising instrument for measuring

Table 2. Final factor structure (factor loadings ≥ 0.40 are presented in bold)

Items	Importance of seeing images	Clearness of the image
1. The image provided clear information about my injury.	-0.01	**0.67**
2. The image was necessary to understand the doctor's explanation of my injury.	**0.70**	0.05
3. Seeing the image allowed me to make a well-considered choice about my follow-up treatment together with my doctor.	**0.61**	0.18
4. I understood the doctor's explanation of the image.	0.13	**0.87**
5. The image motivated me to adhere to the doctor's recommendations.	**0.76**	0.12
6. I am confident that an image contributes to a correct diagnosis of my injury.	0.15	**0.71**
7. Prior to my treatment, I expected to see images during a consultation.	**0.55**	0.00
8. Seeing the image of my injury was very important to me.	**0.77**	0.06
9. When I got home, I could remember the information about my injury because I had seen an image during my consultation.	**0.55**	0.02
10. The image made the explanation of my injury more understandable.	**0.60**	0.35
11. I think the image provided me with a reliable impression of my injury.	0.15	**0.75**
12. Seeing the image during consultations was reassuring for me.	**0.62**	0.14
13. The image motivated me to work on my recovery.	**0.73**	0.13
Eigenvalue	4.469	1.968
Explained variance	30.49%	19.02%

patients' satisfaction with imaging-based information in greater detail, and, as such, is an expedient tool through which to further improve patient care and explore differences in satisfaction across patient groups and imaging techniques.

Studies could use QPSI to explore what type of image (e.g., 2D or 3D) leads to higher satisfaction and better understanding by certain groups of patients. Showing patients their preferred type of image about their injury can help them to be more involved in the decision-making process of their treatment.[3,22,23] Facilitating shared decision-making could prove to be especially important for trauma patients, insofar as it has been reported that communication with physicians strongly influences the overall level of satisfaction that trauma patients have with healthcare.[32]

PCAs resulted in a final multidimensional factor structure with two relatively independent components of satisfaction, which were interpreted as 'the importance of seeing images' with nine related items and the 'clearness of the image' with four related items. Both factors showed adequate internal consistency. The inter-factor correlation was low, thus indicating that the factors measure different aspects of satisfaction and, hence, that it would not be justified to measure patients' satisfaction with imaging as one total score.[33] In addition to their weak intercorrelation, multivariate regression showed that both factors were independently predictive of patients' scores on the global rating scale about their satisfaction with imaging. However, the total explained variance in global satisfaction for the two subscales was only modest, thus suggesting that patients' satisfaction with imaging is also driven by additional factors than merely the importance and clearness of imaging. At this juncture, it is unclear what other factors influence patients' satisfaction with imaging, but one potential explanation is that patients' satisfaction is predominantly influenced by more stable personality traits of patients themselves.[34] Of course, further research is needed to both test this hypothesis and to indicate what other variables predict patients' satisfaction with imaging. Additionally, the global satisfaction rating scale was only used in this study to examine the discriminative validity of the two dimensions underlying the final 13 items. Another approach to select the most relevant items for the QPSI could have been to specifically select those individual items that are most predictive of this global satisfaction score (e.g., by regression analyses) or some other primary or topline metric. Future studies could still use such an approach to further shorten the QPSI while maximizing its predictive value.

Given that QPSI is the first questionnaire to measure patients' satisfaction with imaging during consultations, it proved difficult to find a theoretical explanation for the two different empirical factors resulting from the PCAs. However, the factor 'clearness of the image' appeared to share some similarity to the aspect 'clearness of information', which was found during the development of the preliminary QPSI and subsequently added to the questionnaire based on interviews with trauma patients. The factor 'the importance of seeing images' is very broad and could be connected to several of the aspects which were found during the development phase. Aspects potentially related to this factor could be expectations or understanding, because patients could either find it important that their expectations are met or could find it more important to see images that increase their understanding of their injury. Given the exploratory nature of the PCAs, it is advised to further study the robustness of the current factor structure amongst other populations (e.g., trauma patients in other hospitals or other types of patient populations), and to further examine how the factors are associated with global satisfaction ratings and treatment outcomes. The meaning of the factor 'the importance of seeing images' could also be researched further by employing qualitative methods, for example, by gathering information from patients and medical specialists via interviews.

A strength of this study was the extensive qualitative development phase of the questionnaire combined with the quantitative field test that was conducted to test the actual performance of the QPSI,[35] due to the fact that a lot of patient experience measures have uncertain validity and reliability.[36] It is expected that QPSI encompasses the most relevant aspects of patients' satisfaction with imaging, because of the multidimensional approach of using both existing literature and direct input from patients. The outcomes of the TSTI also confirm that no topics are missing within QPSI and that the items are understandable to patients. Although nine items were deleted during the field testing, it is expected that QPSI still measures the relevant topics, because all aspects related to patients' satisfaction with imaging from the development phase are still included. Therefore, it is not expected that the exclusion of items led to a decrease in the content validity of the measure. Based on these steps, it is assumed that QPSI is a feasible, valid and reliable instrument for measuring patients' satisfaction with imaging.

One potential limitation of this study pertains to the fact that the researcher was present to observe if respondents experienced any difficulties with completing the QPSI, which could have resulted in more socially desirable answers.[37] Ultimately, the decision for the researcher to be present during the completing of the QPSI was made, because it leads to higher response rates and respondents are more likely to answer all of the questions than when no researcher is present.[38] Another limitation is that the vast majority of patients in this study were shown x-rays, while only a few patients saw another type of image. This means

that the conclusions of this psychometric study are mostly specific to patients who saw x-rays and that it should be further tested if similar results will be achieved when patients see other types of images. Therefore, future studies are needed to evaluate the measurement capabilities of the instrument across different imaging techniques, as well as to examine potential differences in satisfaction between patients who were shown different types of images.

For future research, it is advised to use QPSI with adequate sample sizes for every type of medical imaging currently in use. Indeed, a previous study revealed that showing 3D images might be more beneficial than 2D images, albeit they used healthy participants instead of patients and the study only focused on CT scans as 2D images.[5] With the use of QPSI, data from patients can now be gathered and compared for different types of medical imaging. Another study found that preferences for certain types of image might differ across groups of patients.[10] Hence, rather than merely looking at differences in satisfaction between different types of injury, QPSI could also be used to provide more in-depth information into which types of image lead to higher levels of satisfaction for which kinds of patients.

To conclude, QPSI is the first validated questionnaire specifically developed for measuring patients' satisfaction with imaging-based patient information during clinical consultations. This study suggests that the final two-dimensional QPSI holds promise as a reliable and valid measure for this purpose. The QPSI can be used to both evaluate patient satisfaction and to optimise the use of medical imaging in patient education prior to treatment.

Acknowledgements

We would like to express our gratitude to A.J. Andela and M.M. Hamminga (University Medical Centre Groningen) for their support and help during the data collection stage of this study.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Appendix

Appendix A. Likert scale questions preliminary QPSI

Items	Formulation (original questions are in Dutch)
Item 1	The image provided clear information about my injury.
Item 2	The image provided a lot of information about my injury.
Item 3	I became anxious when I first saw the image.
Item 4	I liked the fact that images were used to explain my injury.
Item 5	The image of my injury evoked many questions.
Item 6	Seeing the image made me understand my injury better.
Item 7	The image was necessary to understand the doctor's explanation of my injury.
Item 8	Seeing the image allowed me to make a well-considered choice about my follow-up treatment together with my doctor.
Item 9	I understood the doctor's explanation of the image.
Item 10	The image really allowed me to see the progress of the injury recovery.
Item 11	Seeing the image was important for my rehabilitation process.
Item 12	The image motivated me to adhere to the doctor's recommendations.
Item 13	I am confident that an image contributes to a correct diagnosis of my injury.
Item 14	Prior to my treatment, I expected to see images during a consultation.
Item 15	I found seeing the image of my injury to be confrontational.
Item 16	I found it difficult to see the exact location of my injury on the image.
Item 17	Seeing the image of my injury was very important to me.
Item 18	When I got home, I could remember the information about my injury because I had seen an image during my consultation.
Item 19	The image made the explanation of my injury more understandable.
Item 20	I think the image provided me with a reliable impression of my injury.
Item 21	Seeing the image during consultations was reassuring for me.
Item 22	The image motivated me to work on my recovery.

Appendix B. Response distribution of the different answer categories

Items	Totally disagree	Disagree	Neutral	Agree	Totally agree
Item 1	0%	0.9%	5.7%	55.7%	37.7%
Item 2	0%	1.9%	17%	50.9%	30.2%
Item 3	65.1%	17.9%	6.6%	5.7%	4.7%
Item 4	0%	0%	4.7%	44.3%	50.9%
Item 5	25.5%	36.8%	22.6%	13.2%	1.9%
Item 6	0%	0.9%	6.6%	56.6%	35.8%
Item 7	2.8%	9.4%	14.2%	50.9%	22.6%
Item 8	1.9%	3.8%	34.9%	39.6%	19.8%
Item 9	0%	0%	1.9%	54.7%	43.4%
Item 10	1.9%	6.6%	21.7%	42.5%	27.4%
Item 11	2.8%	6.6%	35.8%	41.5%	13.2%
Item 12	2.8%	3.8%	25.5%	45.3%	22.6%
Item 13	0%	0.9%	7.5%	46.2%	45.3%
Item 14	3.8%	13.2%	23.6%	35.8%	23.6%
Item 15	47.2%	33.0%	9.4%	5.7%	4.7%
Item 16	47.2%	31.1%	2.8%	13.2%	5.7%
Item 17	2.8%	4.7%	19.8%	49.1%	23.6%
Item 18	3.8%	2.8%	16.0%	54.7%	22.6%
Item 19	1.9%	0.9%	7.5%	57.5%	32.1%
Item 20	0%	0.9%	2.8%	59.4%	36.8%
Item 21	0.9%	0.9%	24.5%	50.9%	22.6%
Item 22	1.9%	4.7%	24.5%	43.4%	25.5%