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Participant Perspectives on Pulse-Echo Ultrasound Technology *vs*. Dual Energy X-Ray Absorptiometry (DXA): A Comparative Study

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Abstract

Background/Aim: Osteoporosis is a global health concern causing severe fractures, and timely diagnosis with thorough bone assessment is crucial for effective management. Diagnostic tools such as Bindex® (a novel ultrasound-based diagnostic technology) and DXA (X-ray-based) play a key role in identifying and assessing bone conditions. This study aimed to evaluate and compare these two approaches' overall acceptability, comfort, and preference. Feelings of pain and perceptions regarding the scan length during the Bindex® scanning procedure were also assessed.

Patients and Methods: Two diagnostic imaging tools were used in this comparative study: Bindex® (pulse-echo ultrasound technology) and DXA (X-ray technology). A bespoke questionnaire was employed to gather the participants' responses, which were coded numerically, and data were analysed statistically.

Results: Despite minor discomfort associated with the gel application, Bindex® received significantly higher acceptability and comfort ratings than DXA, with many participants preferring its non-ionising radiation. Both methods were generally well-received, though some favoured DXA for not requiring gel.

Conclusion: In addition to enhancing diagnostic workflows, we demonstrated that Bindex® scans can improve patient satisfaction. This study emphasised the importance of innovating medical imaging diagnostic tools to prioritise patient acceptability and comfort.

Keywords: Bone health, osteoporosis, Bindex®, DXA, DEXA, patient acceptability, patient comfort, quantitative ultrasound, QUS, dual energy X-ray absorptiometry.

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Introduction

Osteoporosis is one of the primary public health issues worldwide. Patients with osteoporosis are more prone to fragility fractures, which can result in significant morbidity, increased mortality rates, and substantial medical costs (1). Early diagnosis followed by a detailed bone health assessment is critical for mitigating these risks and effectively managing and minimising osteoporotic fractures. While DXA remains the standard for bone health assessment, limitations regarding exposure to ionising radiation, accessibility, cost, and extended scan durations for Dual Energy X-ray absorptiometry (DXA) scans, a widely used diagnostic tool for assessing bone mineral density (BMD), have resulted in the need for an exploration of more accessible alternatives that can accurately diagnose bone ailments. In 2023, the Royal Osteoporosis Society (ROS) stated that there was a nationwide deficit of DXA scanners and operators resulting in extended patient wait times and delays in diagnosing and treating a variety of bone conditions (2). Furthermore, current literature posits that DXA can be inexpedient and less comfortable for some patients (3, 4).

Contemporary medical imaging technology has enhanced the diagnosis and management of numerous conditions including osteoporosis. Bindex®, a non-invasive and radiation-free scanner, is an emerging technology for assessment of bone conditions and detect the onset of osteoporosis (5-7). However, the utilisation of Bindex® in a clinical environment is dependent on its efficacy and acceptance by patients. Patient acceptance is determined by a readiness to engage with an unfamiliar medical procedure. This engagement depends on their judgements regarding the advantages, disadvantages, and perceived effectiveness at treating their condition (8, 9). The acceptance of an unfamiliar diagnostic technology (such as Bindex®) is conditional: it depends on many factors including safety, convenience, invasiveness, and a correlation with patient preferences.

Patient satisfaction is a key consideration when introducing innovative medical procedures. Patients are often unwilling to be exposed to new medical methodologies due to uncertainty, inexperience of the treatment, perceived risks and adverse outcomes. Other factors include concern about experiencing pain or discomfort, anxiety regarding the accuracy of the results, and concern about the reliability of innovative technology. Patient satisfaction is complex and encompasses numerous factors such as the quality of medical provision, patient experience and outcomes (10). Within the framework of medical imaging diagnostics, patient satisfaction is assessed *via* patient comfort, safety convenience and improved patient outcomes (11).

Bindex® technology has demonstrated favourable levels of performance in the diagnosis of osteoporosis (5, 6, 12) and is, therefore, a prime candidate for research regarding its acceptance among patients. The development of a robust understanding of patient expectations and perspectives regarding Bindex® is fundamental in overcoming potential barriers to its effective introduction, widespread use, and the provision of effective patient care. Yet, there is no current literature on patient perceptions of this emerging technology. Thus, it is imperative to conduct a thorough assessment regarding patient perceptions of Bindex® to accurately identify the factors which influence patient satisfaction. This study was conducted to assess the patient acceptability and physical comfort of Bindex® as a method for bone health evaluation as compared to the current DXA paradigm. We examined to what extent the participants are willing to accept the new bone health scanning technologies and how widely this acceptance is disseminated among the patient population.

Patients and Methods

Study design and participants. This cross-sectional study was conducted between May 2022 and July 2024, involving 168 participants. Participants underwent both Bindex® and DXA scans. Inclusion criteria ensured participants were capable of completing both scans, while those unable to do so were excluded.

Table I. Participant characteristics.

Sex	Male (n=48) 28.6%		Female (n=120) 71.4%	
Characteristics	Mean±SD	Range	Mean±SD	Range
Age (years)	65±10	(43-89)	63±11	(41-89)
Height (cm)	176±7	(154-186)	162±7	(146-180)
Weight (kg)	84±13	(54-123)	70±14	(40-119)
BMI (kg/m^2)	27.15±4.05	(18.5-38.82)	26.69±5.20	(16.02-42.67)

Ethical approval. This study received approval from the Integrated Research Application System (IRAS), reference number 277369. The participants were anonymously coded.

Data collection. Participants completed an anonymous, coded questionnaire after experiencing both Bindex® and DXA scans. To address the lack of existing research in this area, we developed a bespoke questionnaire tailored to its aims, featuring simple and clear questions that were easy to complete. The questionnaire (supplementary material) consisted of acceptability and physical comfort ratings on a 5-point Likert scale, pain experience and scan duration evaluation and preference for one of the scanning methods with a rationale.

The first two questions (addressing patient acceptability and physical comfort) were presented on the Likert scale consisting of five options: highly accepted, moderately accepted, neutral, not accepted and highly unaccepted. Questions three and four examined pain and the duration of the Bindex® scan and participants were required to select one of two options: Yes or No and Clarify if they answered yes (an additional space was provided for those who selected yes and clarify). The fifth question required the participant to select which scan technology they favoured and why they had selected this option and space was supplied for a detailed response.

Data analysis. Participants' responses, initially expressed in words, were converted to numerical values to enable a structured analysis of physical comfort and general acceptability. These were assessed using a 5-point scale: a score of 1 indicated "highly uncomfortable" or "highly unacceptable", 2 represented "not accepted" or "not comfortable", 3 was "neutral", 4 signified "moderately accepted" or "moderately comfortable", and 5 indicated "highly accepted" or "highly comfortable". This conversion allowed for a standardised quantitative analysis, facilitating the identification of response patterns and enabling statistical comparisons across the data.

The data was managed and analysed using IBM SPSS (Chicago, IL, USA) (version 29.0.1.0). Descriptive statistics summarised demographic data and response patterns. An independent one-tailed *t*-test compared acceptability and comfort ratings between the two scanning methods. Graphs and charts were generated to visualise key findings.

Results

Participant characteristics. This study consisted of 168 participants: 48 males (28.6%) and 120 females (71.4%), aged 40 to 89 years. Participants' characteristics are summarised in Table I. No participant withdrew from the research at any stage resulting in a 100% participant retention rate.

Acceptability of Bindex® vs. DXA. Both scanner methodologies generally received high acceptability ratings, with Bindex® rated as acceptable by 99.4% of participants compared to 98.8% for DXA. Bindex® received 167 (99.4%) acceptable responses and only one neutral rating (0.6%); DXA was rated as acceptable by 166 (98.8%) participants and received two neutral ratings (1.2%). No participants rated the scanning as unacceptable, demonstrating wide acceptance of both

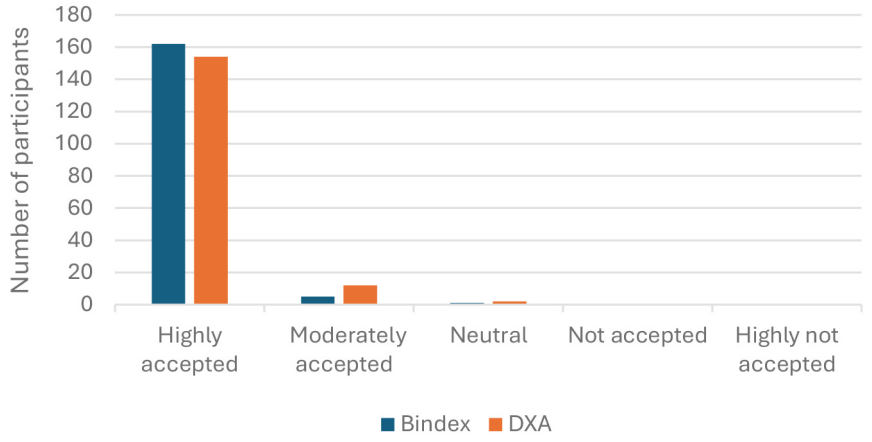

Figure 1. *The degree of general acceptance of both scanning techniques.*

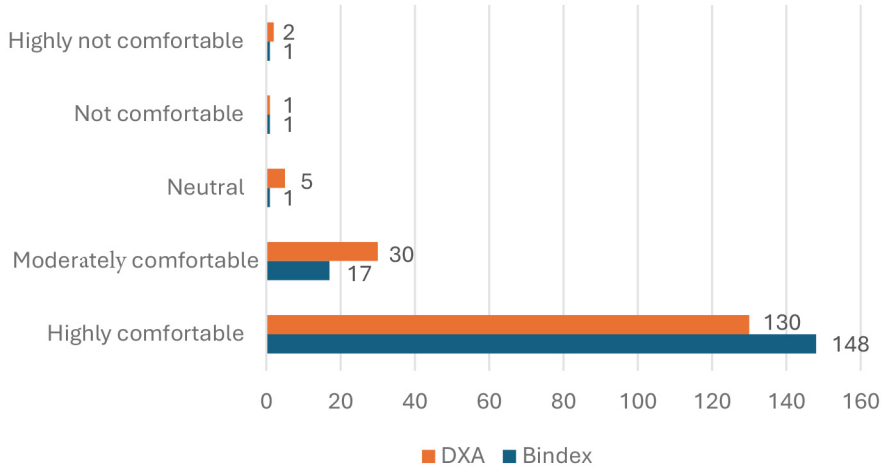

Figure 2. *Illustration of the degree of physical comfort for both scanners.*

scanners. Results are summarised in Figure 1. The mean overall acceptability score for Bendix was significantly higher compared to DXA (4.96 *vs.* 4.90; p=0.043).

Physical comfort of Bindex® vs. DXA. Comfort ratings were similarly high between Bindex® *vs.* DXA, but Bindex® demonstrated a slight advantage, with fewer neutral or uncomfortable responses. Bindex® received 165 (98.2%) ratings categorised as comfortable, one rating of neutral (0.6%), one rating of moderately uncomfortable (0.6%), and one rating of highly uncomfortable (0.6%). The DXA scan was rated as comfortable by 160 (95.3%) participants, with five neutral ratings, and three ratings of uncomfortable (1.8%). Results are illustrated in Figure 2. The mean overall physical comfort score for Bendix was significantly higher compared to DXA (4.85 *vs.* 4.70; p=0.011).

Participant preferences of Bindex® vs. DXA. Examining participant responses concerning their preference for Bindex® or DXA showed that 53 of the participants expressed a preference for Bindex®, 28 participants preferred both scanners and 35 participants preferred DXA. Participants who favoured the Bindex® scan said that "it has non-ionising radiation", and those who

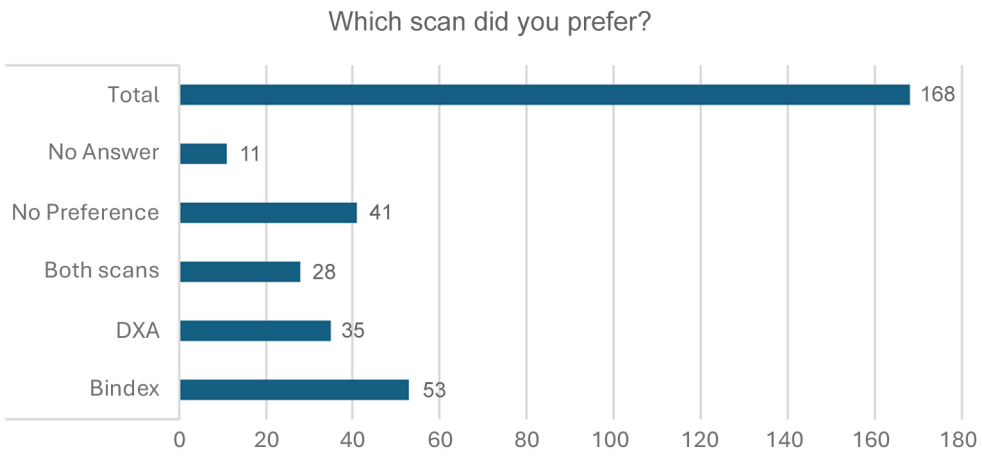

Figure 3. *Levels of preference of both scanners between participants.*

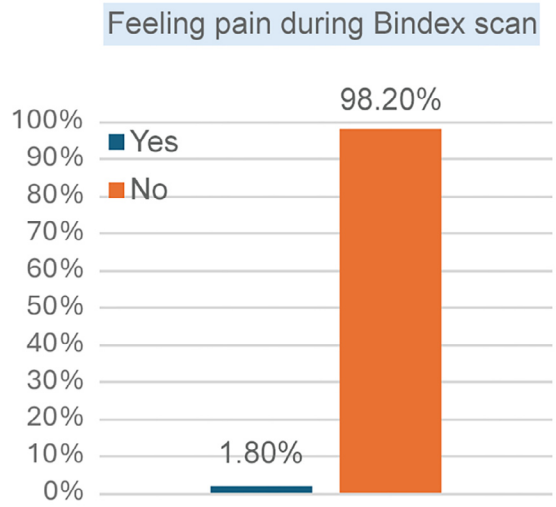

Figure 4. *Participants responses regarding their feelings of pain during Bindex® scan.*

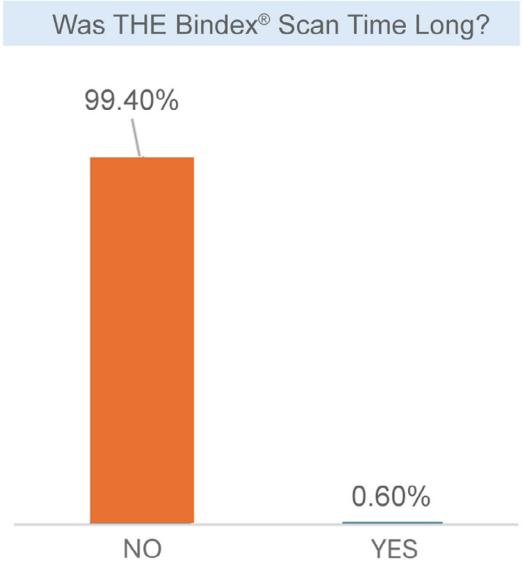

Figure 5. *Participant responses and perceptions of the Bindex® scan-time.*

preferred the DXA scan noted that "no messy gel was used". Notably, a substantial number of participants (24.4%) expressed no preference or did not respond (6.5%), highlighting the overall acceptability of both methods as shown in Figure 3.

Pain during Bindex® scan. Bindex® was perceived as painless procedure by 98.2% of participants, although minor discomfort was reported by a small fraction (1.8%) due to gel application. The results are shown in Figure 4.

Perceptions of Bindex® scan duration. The majority of participants (99.4%) described the Bindex® scan duration as not perceived as lengthy. Results are shown in Figure 5.

Discussion

Osteoporosis is a significant global health issue leading to serious fractures. This underscores the importance of timely diagnosis and comprehensive bone health evaluation

for appropriate management. Diagnostic tools such as DXA and Bindex® are essential for accurate diagnosis and assessment. We aimed to compare participant perspectives on Bindex® and DXA scanning methodologies by evaluating overall acceptability and comfort, as well as assessing pain experienced and perceptions of scan duration during the Bindex® scan. Our results showed that Bindex® had significantly higher acceptability and comfort ratings compared to DXA. This aligns with prior research demonstrating the potential of ultrasound-based technologies to improve patient outcomes and satisfaction in diagnostic imaging (13, 14). Overall, both methodologies were widely accepted by participants of both sexes; however, a significant number expressed no strong preference between the two methods. While both scans were well-tolerated, Bindex® was preferred by some participants for its non-ionising radiation, whereas DXA was favoured by others for not requiring gel.

On the condition that the BMD measurements are validated, these results signify that healthcare services should incorporate Bindex® into their current methodology. Our findings can be employed to enhance equipment design, refine procedural conventions, increase patient knowledge, and ultimately improve the patient experience and acceptance of Bindex® in clinical practice. Positive patient interactions with new scanning technologies can augment the widespread clinical adoption of this approach and increase the number of early diagnoses of osteoporosis which enables more effective treatment. This is in accordance with the work of Sekhon *et al.*, which states that patient acceptability of new procedures increases the inclination of medical professionals to adopt innovative technology and deliver it with increased flexibility and encourages researchers to conduct additional exploration of this new intervention (9). The findings of this study also corroborate the claims made about Bindex® that it is a user-friendly, economical, and benign method for assessing bone status in a clinical and general population context (5-7, 12, 15).

When creating, evaluating, and applying a new medical technique or healthcare service, it is crucial to develop a thorough understanding of the participants' acceptability levels. Current literature suggests that patients are more receptive to treatment and medication if they value and accept the intervention (9). While the effective adoption of a new paradigm depends on each individual's acceptance of a healthcare service, a procedure which does not gain patient acceptability, may not be implemented, negatively impacting the overall effectiveness of the service (16).

Another crucial factor in determining patient satisfaction is the level of physical comfort experienced during the scanning process. Richardson *et al.* performed an interview study with female participants, to assess their awareness of the DXA examination (17). The participants reported that contrary to their expectations, the DXA scan was a positive experience. Throughout the interview process, the researcher recorded the use of words with positive connotations such as 'relaxed' and 'comfortable.' Although the study conducted by Richardson *et al.* consisted of a small number of female participants (17), the results align with the findings of our study regarding participant comfort throughout the DXA scan. Both scanners were assessed as being highly comfortable by the majority of participants, although overall, Bindex® received a higher comfort level rating than DXA. Two additional factors can impact patient comfort: the duration of the scan and the pain (or discomfort) associated with the procedure (18); the minimisation of both can improve diagnostic outcomes. Reduced scan durations reduce patient anxiety (19) and increase well-being during the procedure. It should be emphasised that healthcare specialists can influence patient judgements and the successful implementation of Bindex® by addressing patient anxiety, providing reassurance (before and during an examination), and ensuring that the patient is fully informed about the procedure.

BMD scanning is typically employed for patients who have experienced fractures due to minor injuries in areas such as the femoral neck or lumbar vertebrae and, due to their injuries, lying prone on their back can be painful (20). In addition, remaining prone for an extended period can cause significant pain and discomfort for patients with an elevated body mass index (BMI) (obesity results in increased curvature of the lumbar vertebrae) that may

cause the participant to move during the scan, which can negatively impact the BMD measurements. Although a DXA scan has a longer duration than a Bindex® scan (approximately 10 min), Richardson *et al.* noted that the efficiency of a DXA examination was a contributing factor to increased participant satisfaction (17). Our study found that 99.4% of participants rated the Bindex® scan time as a quick scan, which potentially provides it with a significant advantage.

While Bindex® is a non-invasive procedure, it should be noted that there is the potential for patients to experience some form of pain or discomfort throughout the procedure. Pain may also occur as a result of the application of pressure by the probe on the scanned area. Yet, the slight discomfort reported with Bindex® can be mitigated through operator training and refinements of the procedure. Additionally, patients with an elevated BMI or lower back issues may experience pain as a result of the examination position. The results of this study revealed that the majority of participants experienced no pain when undergoing a Bindex® scan. However, the Bindex® scan does possess one negative factor: the 'messy gel' (although this may be explained by the operator's lack of experience). The preference for non-gel-based DXA scans signifies that the thoughts and feelings of the participants should be considered before the introduction of a new diagnostic paradigm.

The preferences expressed by some of the participants towards the Bindex® scan occurred because of their understanding and appreciation of the hazards of radiation. Participants favour efficient and simple procedures that result in a reliable diagnosis and treatment. There are two principal reasons behind preferences from individuals found in the current study. DXA was preferred because the scan did not involve the use of "messy gel", while those who preferred Bindex® did so because it does not use ionising radiation. This signifies an awareness of the risks of radiation among the participants, which concurs with the findings of Ribeiro *et al.* who noted the need to increase public awareness and understanding of the dangers of ionising radiation in medical imaging (21).

A key strength of this study is that it focused on participants over the age of 40 for two reasons: a) they are at an age of increased risk for osteoporosis or other age-related bone conditions, and b) their experiences make their views valuable for evaluating the comfort and acceptability of both scanners. Yet, the main limitation of this study includes an ethnically homogenous (95.2% English) and predominantly female sample (71.4%) which may affect generalisability. Thus, the results of this study cannot be widely applied to the wider population. Future research needs to explore more diverse populations to improve the generalisability and validity of our findings.

Conclusion

By offering high acceptability and comfort, this study demonstrated that Bindex® has strong potential as an alternative to DXA in clinical practice settings. This study emphasises that research based on patient-centred innovative imaging approaches is crucial to enhance diagnostic technologies and ultimately improve patient outcomes.

Supplementary Material

Supplementary material related to this study can be found at: https://figshare.com/articles/dataset/Questionnaire_of_Bindex_vs_DXA_Acceptability_/28136213?file=51478337

Conflicts of Interest

The Authors declare that they have no conflicts of interest that are directly relevant to the content of this study.

Authors' Contributions

AA collected the data, performed statistical analyses, created the graphs, interpreted the results and drafted the manuscript. MA contributed to data collection. KM contributed to critical discussions. RM, JF, WDS, and KK supervised study.

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