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ORIGINAL ARTICLE
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Whole Body Radiography for Bone Survey Screening of Cancer and Myeloma Patients

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ABSTRACT

***Purpose*: To determine the utility of a rapid, low dose whole body radiographic system (Statscan) for the detection of focal metastatic deposits in cancer patients and multifocal disease in myeloma patients. *Materials and Methods*: After IRB approval, 30 consecutive patients had a frontal and lateral whole body radiography done with the Statscan system as a substitute for conventional radiographic skeletal survey. Both whole body images were obtained in less than five minutes. Images were retrospectively reviewed, independently, by three musculoskeletal radiologists. Findings were compared to information from all other available imaging studies. Final determinations were by consensus. *Results*: Of the 30 patients in the study group, there were 18 men and 12 women with an age range from 37 to 88 years, average 60 years. Diagnoses were MGUS/multiple myeloma in 18 cases, lymphoma/leukemia in two cases, and cancer in 11 cases. Eleven of the Statscan exams were interpreted by all three radiologists as normal. The remaining 19 Statscan exams showed a total of 117 lesions (96 osteolytic and 21 osteoblastic). Ninety percent of these (106/117) were confirmed as areas of suspected metastatic disease or multifocal involvement by a variety of other imaging studies (radiographic bone survey—7, CT—33, MR—13, bone scan—4, PET/CT—8). *Conclusion*: The Statscan whole body radiographic system is a useful method for detecting focal metastatic disease in cancer patients and multifocal involvement in myeloma patients.**

INTRODUCTION

Patients who are diagnosed with cancer, multiple myeloma and other malignancies often need screening studies of the entire skeleton done to establish the presence or absence of metastatic disease or multifocal involvement. Despite their low sensitivity, standard radiographic bone surveys are still one of the most common studies done to accomplish this screening because of their ready availability and low cost. Other methods with higher sensitivity often are employed as well, including Tc-99m scintigraphy and F-18 FDG PET/CT. Whole body MR imaging and whole body CT may be used in some patients. The standard radiographic bone survey requires multiple exposures of individual portions of the skeleton and takes approximately 30–45 minutes to complete (1, 2). At least two new rapid, low dose, whole body radiographic systems are now available. These systems are primarily being used to evaluate pediatric and adult trauma patients (3–5) but are also said to be useful for imaging the spine in scoliosis patients and the lower limbs for length and alignment prior to total joint replacement. Some of these uses and other potential uses have not yet been evaluated and reported in the literature. We sought to determine the utility of one of these rapid low dose, whole body radiographic systems (Statscan, Lodox Systems, North America, South Lyon, Michigan, USA) for the task of bone survey screening in cancer and myeloma patients.

Keywords: Metastatic disease, Screening, Whole body radiography.
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MATERIALS AND METHODS

A retrospective review of 30 consecutive patients was done by three musculoskeletal radiologists independently. Final

(A) (B)

Figure 1. Representative whole body AP (A) and lateral (B) Statscan images. No lesions were detected other than incidental left femoral enchondroma (arrow).

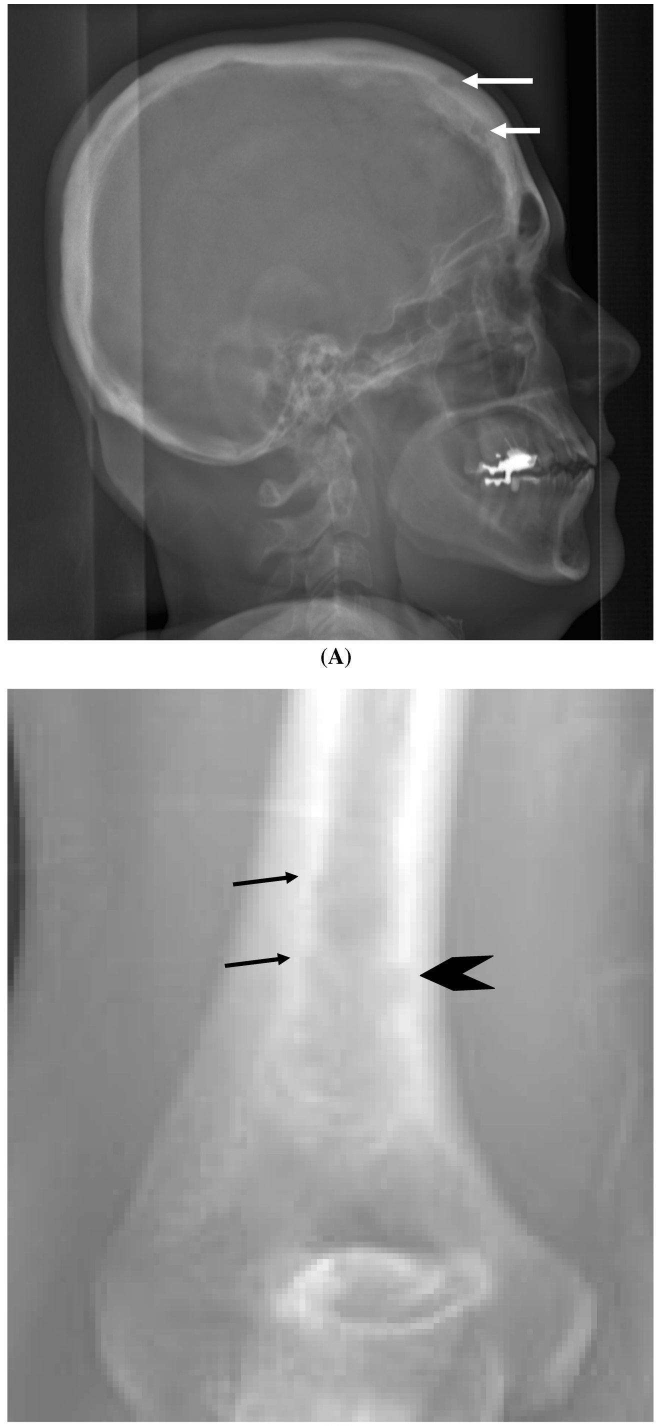
determinations were by consensus. Experience levels for the radiologists were >20 years for reader one, >9 years for reader two and >1 year for reader three. Patients had to have had a bone survey done using the Statscan and at least one other imaging study done within 18 months to be included in this study. The Statscan survey consists of whole body AP from top of skull to ankles and lateral from top of skull to coccyx (Fig. 1). Statscan images were acquired in standard mode, with a resolution of 1.4 line pairs per millimeter. Conventional radiographic bone surveys, at our institution, are done with computed or direct radiographic systems that have line pair resolution ranging from 2.5–5.0.

Figure 2. Lateral skull image considered nondiagnostic due to cutoff of frontal bones.

Patients were identified by searching our PACS system procedure field for the skeletal survey code number. There were 99 bone surveys done in a 12 month period of time. Thirty-five of these bone surveys were done using the Statscan. However, five of these patients did not have any other relevant imaging studies done within 18 months of the Statscan and, thus, were excluded. The radiologists independently reviewed the remaining 30 Statscans on our regular PACS workstations that are equipped with 2K monitors. They recorded the number of osteolytic and/or osteoblastic lesions and site of involvement. An assessment of Statscan image quality (diagnostic, marginal or nondiagnostic) was done compared to our conventional radiographic survey. Statscans were considered "nondiagnostic" if some critical portion of the skeleton was not felt to be imaged adequately (Fig. 2). Total number of Statscan images for each patient was also recorded. Patient's diagnoses were known to the readers. One month later all other relevant imaging studies were reviewed independently noting number of osteolytic and/or osteoblastic lesions and site of involvement. When a conventional radiographic bone survey was reviewed, the total number of images obtained was recorded. Finally, all cases were reviewed by all three readers together to achieve consensus. The study was approved by our institutional IRB.

RESULTS

Of the 30 patients in the study group, there were 18 men and 12 women with an age range from 37 to 88 years, average 60 years. Diagnoses were MGUS/multiple myeloma in 18 cases, lymphoma/leukemia in two cases (NHL and AML), cancer in 11 cases (breast—1, lung—1, glioma—1, renal cell—1, bladder—2, pancreas—1, prostate—1, and unknown primary—3). One patient had both MGUS and renal cell carcinoma. An average of 3 Statscan images was needed for complete evaluation. A separate lateral view of the skull accounted for this. Eleven of the Statscans were interpreted by all three radiologists as normal. Other imaging studies in these cases for each individual patient included standard radiographic bone surveys in four cases, chest-abdomen-pelvis CT exams in three cases, CT abdomen-pelvis in one case, MR of the spine with CT of the chest and a bone scan in one case, and PET/CT in one case. These studies were also all normal in these 11 cases. The remaining 19 Statscans showed a total of 117 lesions (96 osteolytic and 21 osteoblastic). Included in the number of osteolytic lesions are 14 spinal compression fractures. Not included in the number of osteolytic lesions are three patients whose skull films had multiple small lesions that could not be individually counted. Ninety percent of these (106/117) were confirmed as areas of suspected metastatic disease or multifocal involvement by a variety of other imaging studies (radiographic bone survey—7, CT—33, MR—13, bone scan—4, PET/CT—8). These comparison studies were done on average within 3.5 months of the Statscan (range 1 day–18 months). The other 11 lesions were not included in the fields of view of the cross sectional imaging studies. There were no discrepancies between any of the Statscans and the conventional radiographic surveys. Three incidental osteolytic or osteoblastic lesions, not considered metastatic or malignant, are included in the totals. There was one distal femoral enchondroma in one patient, a femoral neck synovial herniation pit in one patient, and a humeral head cyst in one patient. Statscan quality was considered good in 23 cases; marginal in 6 cases and nondiagnostic in 1 case by reader number one; good in 19 cases; marginal in 8 cases; and nondiagnostic in 3 cases by reader number two; good in 18 cases and marginal in 12 cases by reader number three. Nondiagnostic exams had small portions of the skull or humeri excluded. Questionable lesions were felt to be present in 4 cases by reader number one; in 11 cases by reader number two; and in 9 cases by reader number three (Fig. 3).



(A)

(B)

Figure 3. Examples of questionable lesions. A) Lateral skull image with two subtle focal lucencies (arrows) that were felt to represent arachnoid granulations. B) Magnified AP view of distal humerus with at least one discrete lesion (arrowhead) but questionable additional foci (arrows).

DISCUSSION

Our results indicate that the Statscan whole body radiographic system is a useful method for detecting focal metastatic lesions

(A) (B)

Figure 4. Comparison of Statscan lateral (A) and reformatted sagittal CT (B). Both studies show compression fracture of T7, but only CT shows multiple additional lesions in adjacent vertebrae.

in cancer patients and lytic lesions in myeloma patients. The Statscan system detected just as many focal lesions as conventional radiographic skeletal surveys, similar to its performance in trauma patients (5, 6). In the current study, there were no discrepancies between the Statscan and the conventional radiographic surveys despite the lower resolution of the Statscan (1.4 lp/mm) versus the CR and DR systems (2.5–5.0 lp/mm). The Statscan does have higher resolution modes available (up to 5.0 lp/mm), but, at the highest resolution, one is able only to image portions of the skeleton (7). We chose the lower level of resolution in order to obtain whole body images. However, for nontrauma patients higher levels of resolution may be desirable since speed and single whole body images are not critical. In our study, the readers did identify a variable number of questionable lesions that seemed to depend on the reader's level of experience. We did not feel that the number of questionable lesions was greater than what would be expected for any conventional radiographic technique, although we did not specifically measure this. As with other simple radiographic methods, the activity of an individual lesion could not be determined.

It is widely known that radiographic surveys are less sensitive for lesion detection than some other whole body techniques, e.g., CT, MR or PET/CT (Fig. 4). For instance, in the staging of myeloma patients it has been shown that MR may reveal abnormalities in up to 36% of cases where the radiographic survey is reported to be normal (8). Likewise PET/CT shows abnormalities in up to 25% of cases where the radiographic survey is reported to be normal (9). These advanced images studies, however, cannot yet entirely replace radiographic surveys since the radiographic surveys may detect additional lesions in up to 20% of cases, even in areas where MR images are reported to

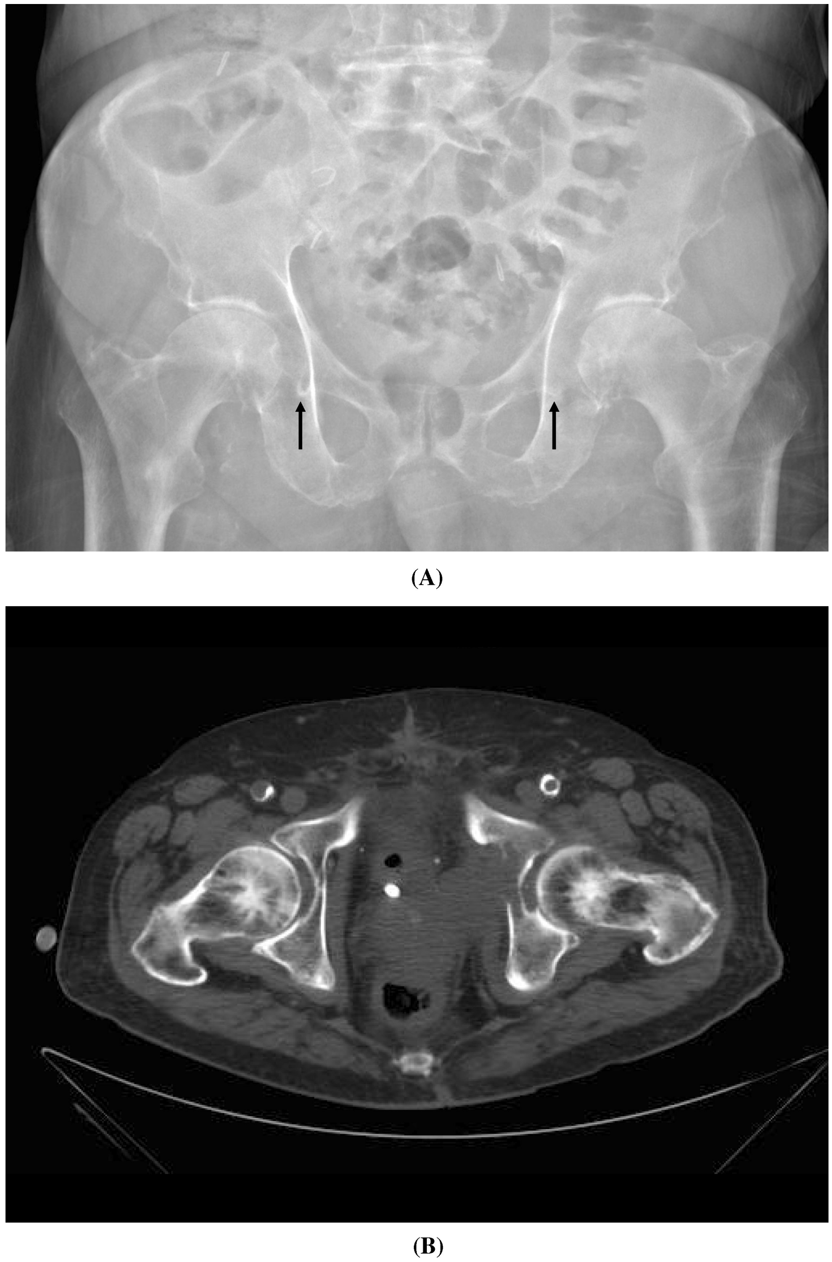


Figure 5. Comparison of magnified Statscan AP view of pelvis (A) and axial CT (B). Loss of left teardrop shadow is evident on radiograph when compared to normal right side (arrows), but is much easier to detect on CT.

be normal (10). A combination of staging studies still seems to be the best approach (11), especially for myeloma patients in whom it is important to know the tumor burden throughout the entire skeleton. Our study supports these views. Similar to other reports in the literature (12) cross sectional imaging studies in our patients did reveal some other lesions in addition to those evident on the Statscan. This issue has not been studied as extensively in cancer patients perhaps because once metastases have appeared anywhere in the skeleton treatment decisions are not as dependent on knowing each and every site of involvement.

Based on our initial results, we feel that radiologists and referring physicians should be as confident with the whole body system as with a conventional radiographic exam regarding the presence or absence of focal lesions (Fig. 5). Other institutions with similar whole body radiographic systems could consider substituting this method for the routine radiographic bone survey when such an exam is requested. Standard radiographic bone surveys require 8–20 different exposures of the skeleton depending on the completeness of the evaluation (1, 2). At our institution, the average is 18 exposures. The patient is typically on the radiographic table for 20–45 minutes. A Statscan takes less than five minutes and requires only three exposures on average. At standard resolution (1.4 lp/mm), the Statscan AP whole body and lateral spine images are acquired in less than 15 seconds each versus 25–45 minutes for multiple conventional or computed radiographs of the typical patient. The Statscan unit is less expensive than a standard radiographic system. The billing cost for a radiographic bone survey is the same at our institution regardless of method used to obtain it.

The Statscan also has the benefit of a lower radiographic dose of 25 to 75% compared to conventional film screen exams. Techniques that allow for doses "as low as reasonably achievable" (ALARA concept) are important in all areas of radiology. Recent emphasis is on lower dose multislice CT techniques, especially for children; however, dose considerations are important for all patients in every setting, especially in light of the latest Biological Effects of Ionizing Radiations report (BEIR VII) that supports a linear no-threshold model of radiation exposure (13). This model implies that even the smallest doses of radiation may have harmful effects.

This study has some limitations. The number of cases is not large but is in keeping with the number of cases in other such studies. The patients did not all have other complete whole body imaging studies to corroborate the Statscan findings, but clinical follow-up has not revealed any significant missed lesions in any of these patients who all have more than one year of follow up since the study was completed. There is no pathologic proof. There are multiple comparison techniques. The study is retrospective, and there was no defined control group. However, our 11 normal cases can be viewed as an internal control.

SUMMARY

Whole body imaging techniques continue to evolve. Rapid, low dose whole body radiographic systems are useful tools not only because of their diagnostic accuracy, speed and dose considerations but also because of their low cost and potential for wide availability.

REFERENCES

1. Ghanem, N.; Lohrmann, C.; Engelhardt, M.; et al. Whole-body MRI in the detection of bone marrow infiltration in patients with plasma cell neoplasms in comparison to the radiological skeletal survey. Eur Radiol **2006**, *4*, 1–10.
2. Mulligan, M. Imaging techniques used in the diagnosis, staging, and follow-up of patients with myeloma. Acta Radiol **2005**, *46*, 716–724.
3. Douglas, T.; Sanders, V.; Pitcher, R.; van As, A.B. Early detection of fractures with low-dose digital x-ray images in a pediatric trauma unit. J Trauma **2007** [Epub ahead of print].
4. Pitcher, R.; van As, A.B.; Sanders, V.; et al. A pilot study evaluating the "Statscan" digital x-ray machine in paediatric polytrauma. Emerg Radiol **2007** [Epub ahead of print].
5. Mulligan, M.; Flye, C. Initial experience with Lodox Statscan imaging system for detecting injuries of the pelvis and appendicular skeleton. Emerg Radiol **2006**, *13*, 129–133.
6. Boffard, K.; Goosen, J.; Plani, F.; Degiannis, E.; Potgieter, H. The use of low dosage X-ray (Lodox/Statscan) in major trauma: comparison between low dose X-ray and conventional x-ray techniques. J Trauma **2006**, *60*, 1175–1181.
7. Miller, L.; Mirvis, S.; Harris, L.; Haan, J. Total-body digital radiography for trauma screening: initial experience. Applied Radiol **2004**, *33*, 8–14.
8. Weber, D.; Dimopoulos, M.; Moulopoulos, L.; Delasalle, K.; Smith, T.; Alexanian, R. Prognostic features of asymptomatic multiple myeloma. Br J Haematol **1997**, *97*, 810–814.
9. Durie, B.; Waxman, A.; D'Agnolo, A.; Williams, C. Whole-body (18)F-FDG PET identifies high-risk myeloma. J Nucl Med **2002**, *43*, 1457–1463.
10. Walker, R.; Barlogie, B.; Haessler, J.; et al. Magnetic resonance imaging in multiple myeloma: diagnostic and clinical implications. J Clin Oncol **2007**, *25*, 1121–1128.
11. Durie, B. The role of anatomic and functional staging in myeloma: description of Durie/Salmon plus staging system. Eur J Cancer **2006**, *42*, 1539–1543.
12. Breyer, R.; Mulligan, M.; Smith, S.; Line, B.; Badros, A. Comparison of imaging with FDG PET/CT with other imaging modalities in myeloma. Skeletal Radiol **2006**, *35*, 632–640.
13. Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation. Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2. Washington, DC: The National Academies Press 2006.