Clinical Evaluation of the Cleon Imager

B. R. J. Williamson, C. D. Teates, B. Y. Howard, R. J. Barczak, and Robert Mosby

University of Virginia, Charlottesville, Virginia

We have compared bone images from a number of patients using three instruments. In 38 patients, Cleon body images were compared with whole-body rectilinear scans. Cleon images were also compared with scintillation camera images of the trunk or extremities of 31 patients and of the skull of 70 patients. The Cleon was superior to the rectilinear scanner in resolution, lesion detectability, and speed of scanning. The Cleon and gamma camera were comparable in lesion detection, but the Cleon was considerably faster. Clinical studies and comparative evaluation are presented.

J Nucl Med 18: 1123–1127

The Cleon imager is a multi-crystal scanner designed for rapid imaging of large areas such as total-body bone scan. The large crystal area allows rapid accumulation of data. Other design features make this instrument valuable for the nuclear medicine laboratory performing a large number of studies. This is a report of our experience with this instrument where comparative bone images were obtained on other imaging devices.

MATERIALS AND METHODS

Over a 4-mo period, we did comparative imaging of patients (referred for bone scans) on three instruments: the Cleon imager, the Ohio Nuclear 84FD rectilinear scanner, and the Searle HP gamma camera. Images were performed with 15 mCi of Tc-99m polyphosphate at 2.5 to 4 hr after injection. There was no set order for the use of the three instruments. A total of 74 patients had studies performed on both the Cleon imager and one of the other instruments (Table 1).

The studies on the Cleon imager consisted of total-body scans with the head in antero-posterior orientation. From time to time supplemental lateral views of the head were obtained in the whole-body mode or "organ" mode. The imaging speed was 10 cm per minute for the lower extremities and 5 cm per minute for the trunk and head. At this scanning rate, the information density over the trunk was usually in the range of 300 to 400 counts per cm^2. Imaging time with this technique is approximately 40 min.

Thirty-eight patients had comparative scans using the whole-body rectilinear scanner. The cranium was not imaged, and a different technique was used over the lower extremities where the scan intensity was increased to allow better definition of low-count-rate areas. The peak information density over the trunk was approximately 400 counts/sq. cm. Two collimators were used during the study: the 24 L medium-resolution collimator with a focal depth of 3 in. and a 35 L collimator focussing at 5 in. The imaging time, including instrument setup, was usually in excess of 1 hr.

Thirty-one patients had comparative body or extremity images on the Cleon imager and the scintillation camera. Usually the camera views were obtained because of a demonstrated lesion or a suspicious area

TABLE 1. CLEON COMPARATIVE STUDY

Area imaged	Instruments compared	Number of patients compared
Trunk and extremities	Ohio Nuclear 84FD vs Cleon	38
Trunk and extremities	Searle HP vs Cleon	31
Skull	Searle HP vs Cleon	70

Received Apr. 18, 1977; revision accepted June 10, 1977.

For reprints contact: Charles D. Teates, Dept. of Radiology, School of Medicine, University of Virginia, Charlottesville, VA 22901.

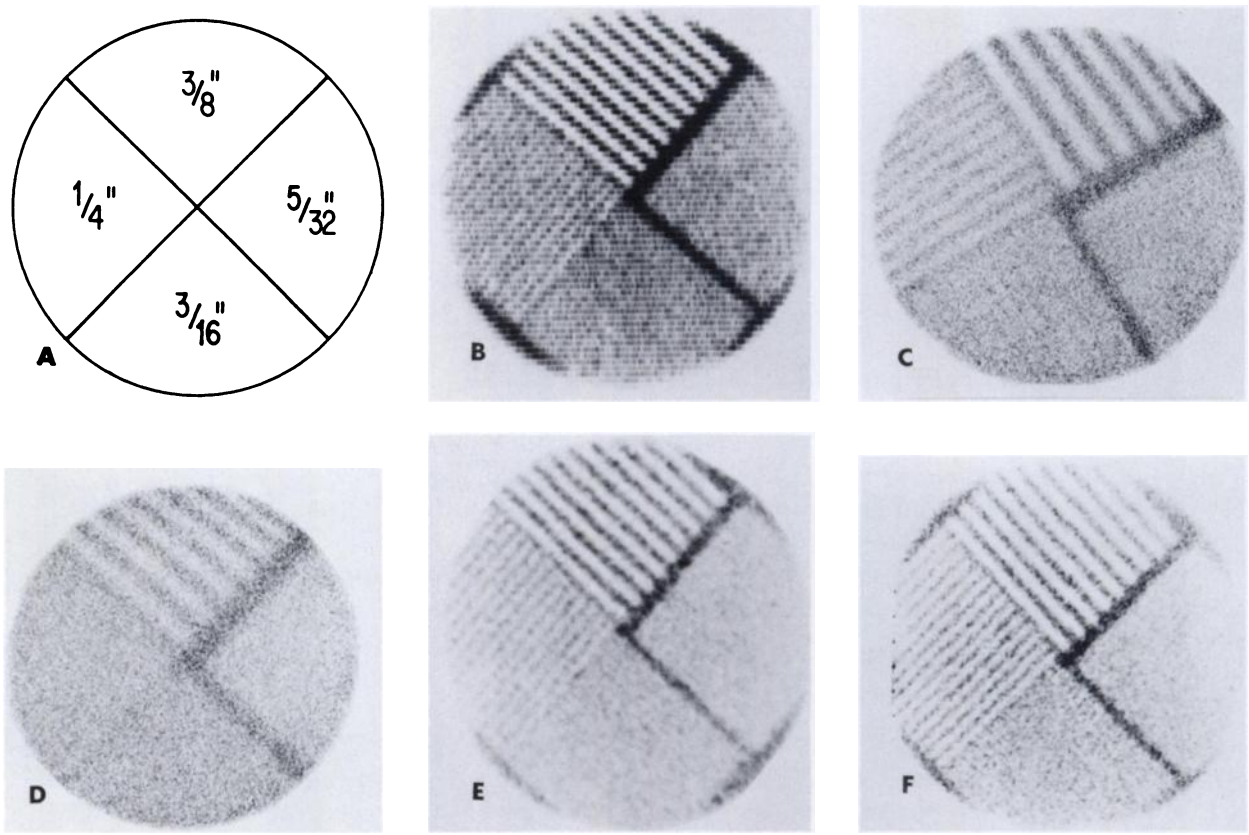

FIG. 1. (A) Spacing data for lead bar phantom used in comparing instrument resolution. (B) Bar-phantom study by Ohio Nuclear 84FD with 24L collimator. Bar phantom is at focal plane, 7.6 cm from collimator. Scanning time is 30 min, with information density (ID) of 800 c/cm² and 4.5 mCi of Tc-99m in flood source. Quarter-inch bars are resolved. (C) Searle-HP study with bar phantom in contact with low-energy all-purpose collimator. Imaging time is 3 min, with ID of 600 c/cm² and 4.5 mCi Tc-99m. Note that Searle images cover only about 50% of phantom. Three-sixteenth-inch bars are faintly seen. (D) Searle-HP study as above with phantom 9.5 cm from collimator. Only the ⅜-in. bars are resolved. (E) Cleon scan, in whole body-mode, with bar phantom at focal plane, 9.5 cm from collimator cover plate. Imaging time (at 5 cm/min) is 8 min, giving an ID of 500 with 4.5 mCi Tc-99m. The ¼-in. bars are resolved, with faint visualization of 3/16-in. bars. (F) Cleon scan, in organ with bar phantom at 9.5 cm. Imaging time 16 min at 2.5 cm/min using 4.5 mCi Tc-99m for an ID of 1000. There is little improvement over the lower-ID, whole-body-mode study, although bars are more sharply delineated.

on the Cleon. Seventy patients had comparative skull views on the camera. These always consisted of four views, even though at times only the anterior and posterior views were obtained on the Cleon. Several low-energy parallel-hole collimators were used on the scintillation camera, including the high-resolution, high-sensitivity, and all-purpose collimators. The camera views contained 150,000 counts. All views were static images.

Bar-phantom studies were performed on all three instruments using approximately 4.5 mCi in a flood source. Figure 1 compares the resolutions of the instruments and the imaging times at the stated information densities. On the rectilinear scanner and Cleon instruments, the bar phantom was placed at the focal plane of the collimator. On the scintillation camera the phantom was imaged in contact with the collimator and also 9.5 cm away.

The patient studies were reviewed by two observ-

TABLE 2. WHOLE-BODY SCANS

Observer	Cleon imager	Ohio Nuclear 84FD
A	1.86*	1.47*
87 lesions	(3 lesions 0)	(6 lesions 0)
B	2.10*	1.82*
89 lesions	(2 lesions 0)	(7 lesions 0)

* Rating is 0 (not seen) to 3. Ten of 38 scans normal.

TABLE 3. BODY IMAGES*

Observer	Cleon imager	Searle HP camera
A 49 lesions	1.78†	1.55† (7 lesions 0)
B 49 lesions	2.39†	1.92† (6 lesions 0)

* The camera's difficulties were largely with spine lesions of one patient.

† Rating is 0 (not seen) to 3. Five of 31 patients normal.

TABLE 4. SKULL IMAGES

Observer	Cleon imager	Searle HP camera
A 34 lesions	1.21* (9 lesions 0)	2.06* 2.28*
B 36 lesions	1.56* (7 lesions 0)	(1 lesion 0)

* Rating 0 (not seen) to 3. Forty-three to 44 of 70 patients normal.

ers. Identifiable areas of abnormal activity that could be compared on the Cleon and at least one of the other instruments were rated for each instrument as 0 (not seen) to 3 (well demonstrated). The results of these comparisons are shown in Tables 2, 3, and 4. Examples of comparative scans are shown in Figs. 2–6.

DISCUSSION

The Cleon imager was designed as a high-speed scanner that is particularly well suited to total-body imaging. It can also be operated in an organ mode to achieve some increase in resolution. There are a total of 10 collimators and crystals in each of the upper and lower probe sets. The total crystal area in each probe set is 697 cm^2, which compares favorably with the 127 cm^2 in a 5-inch rectilinear probe or the 560 cm^2 in our scintillation camera. The linear motion of the Cleon imager is variable between 20 cm/min and 2.5 cm/min. There is essentially no setup time with the Cleon, and the data are stored on a disc recorder so that additional images may be obtained at different intensity settings or with background erase or enhancement. This disc may also be permanently filed. The Cleon uses 20 parabolic focused collimators converging at 12 cm with a relatively large depth of field. The manufacturer claims an 8-mm resolution (full width at half maximum) at the focal plane. The images may be recorded on Polaroid film or an 8- by 10-in. (20.3 × 25.4 cm) transparency.

Cleon images have inherently more contrast than those obtained with the other two instruments. One can take advantage of the inherent higher contrast by using repeat exposures from the disc storage at several different intensity settings.

The resolution on the bar phantom is better with the Cleon imager than with the rectilinear scanner, whether with 3-in. or 5-in. collimator focal length. In addition, the increased depth of field with the parabolic collimators allows good resolution of more lesions than one obtains with the focussed collimators of the rectilinear scanner. Although bar-phantom resolution is comparable with the Cleon and the scin-

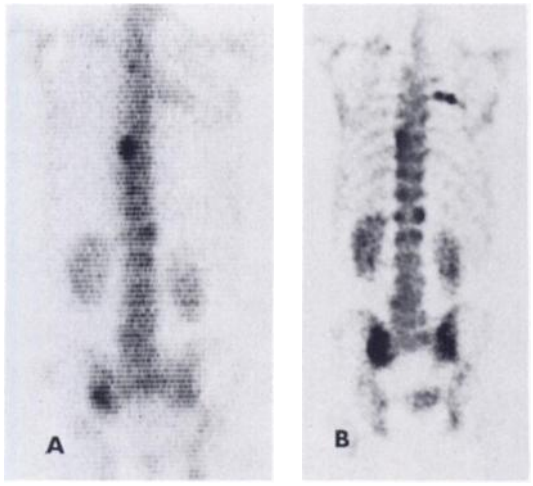

FIG. 2. (A) Portion of Ohio Nuclear 84FD whole-body posterior scan of patient with multiple prostatic metastases. Lesions in right ribs are poorly resolved, being superficial to focal plane. Mid-dorsal and sacral spine lesions are visualized. A metastasis in L1 is faintly detected. Patient study with 15 mCi of Tc-99m pyrophosphate. (B) Same patient as (A) scanned the same day with the Cleon in whole-body mode. All lesions are better visualized. Note improved detail of ribs and spine.

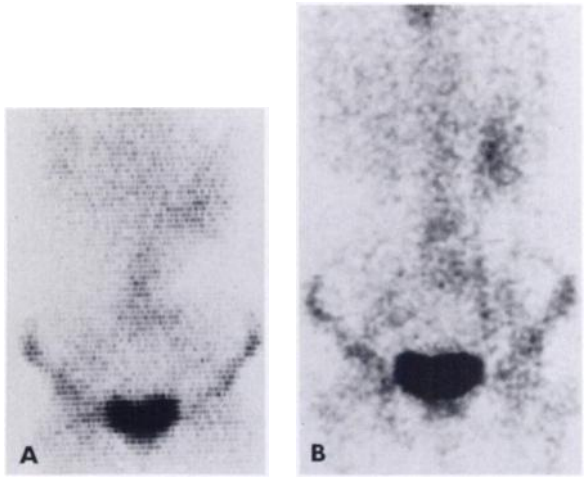

FIG. 3. (A) Anterior whole-body scan with 15 mCi of Tc-99m pyrophosphate and Ohio Nuclear 84FD. Left hydronephrosis is faintly detected in this patient with carcinoma of cervix. (B) Cleon whole-body study same day shows renal activity and hydroureter with better detail.

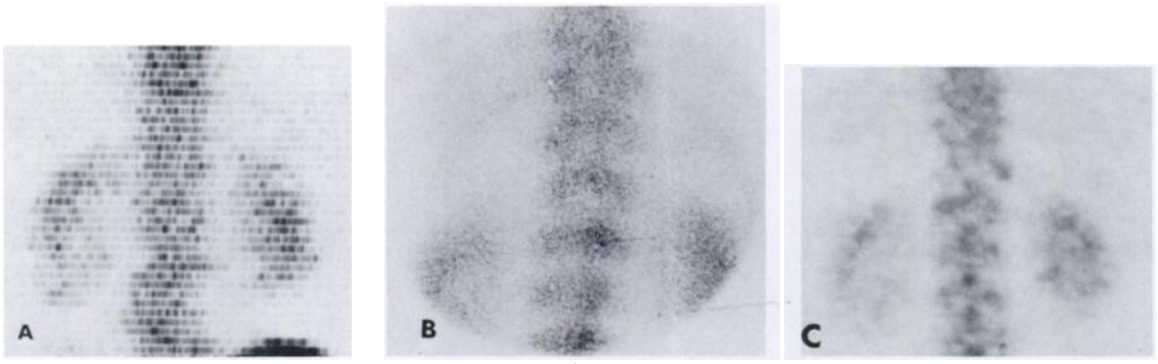

FIG. 4. (A) Posterior view of spine in whole-body scan of patient with carcinoma of prostate. This Ohio Nuclear study of spine with Tc-99m pyrophosphate appears normal .(B) Searle HP static view on same day appears normal. (C) Cleon whole-body scan detected focal lesion in right side of T-12.

tillation camera, on deeper lesions the Cleon is probably superior, as demonstrated in figures 1D and 1E.

The Cleon imager performed clearly better than the rectilinear dual-probe scanner in terms of speed of imaging and resolution of lesions. Both observers rated the Cleon clearly higher on lesion visibility and delineation. A number of lesions were seen on the Cleon but not on the rectilinear scanner and rarely did the converse situation occur (see lesions rated 0 in Table 2).

In comparing views of the trunk and extremities, the overall rating for the Cleon was superior to that in the scintillation camera. The superior rating for the Cleon, however, was largely due to one patient where there were a number of lesions seen with the Cleon that were not definitely identified by the camera. The overall impression was that static body images were comparable on the two instruments. Obviously the Cleon is superior to the camera in terms of the time required for total-body imaging.

Our initial experience with skull imaging with the Cleon was disappointing. As we have had more experience with the instrument, we have been able to improve the skull-imaging technique to where the Cleon and camera are comparable, and we no longer perform our skull images on the camera (Fig. 6). We found that part of the difficulty in imaging the skull was related to the information density, and we now perform our skull images on the Cleon at 2.5 cm linear movement per minute. Four views are routinely obtained on the Cleon.

CONCLUSION

We have found that the Cleon imager is indeed a high-speed instrument that is quite well suited to

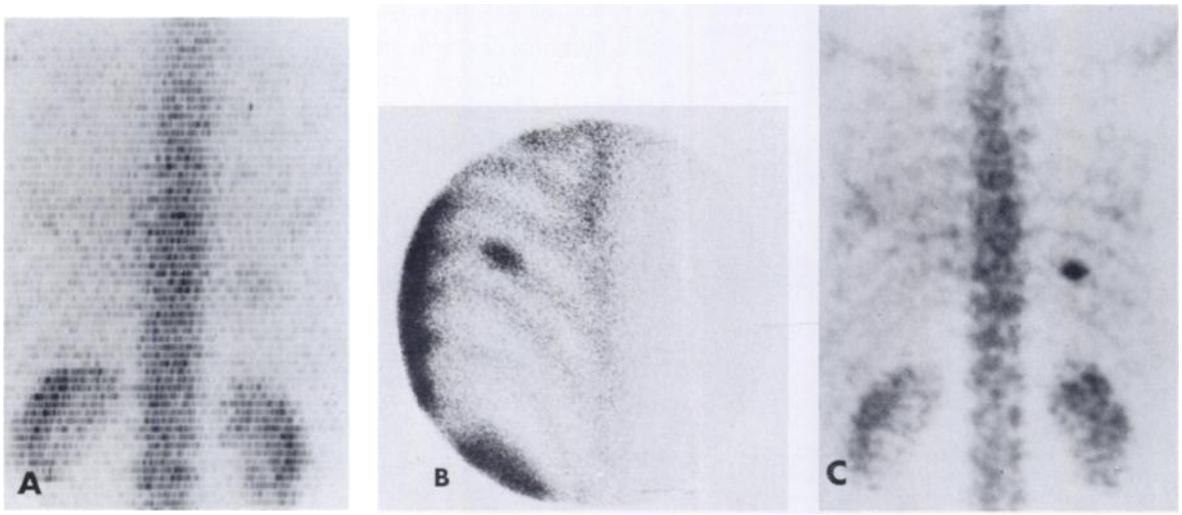

FIG. 5. (A) Whole-body scan with Tc-99m pyrophosphate and Ohio Nuclear 84FD faintly detected right rib metastasis from carcinoma of prostate. (B) Searle HP static view same day clearly shows lesion. (C) Same day whole-body images with Cleon clearly shows lesion.

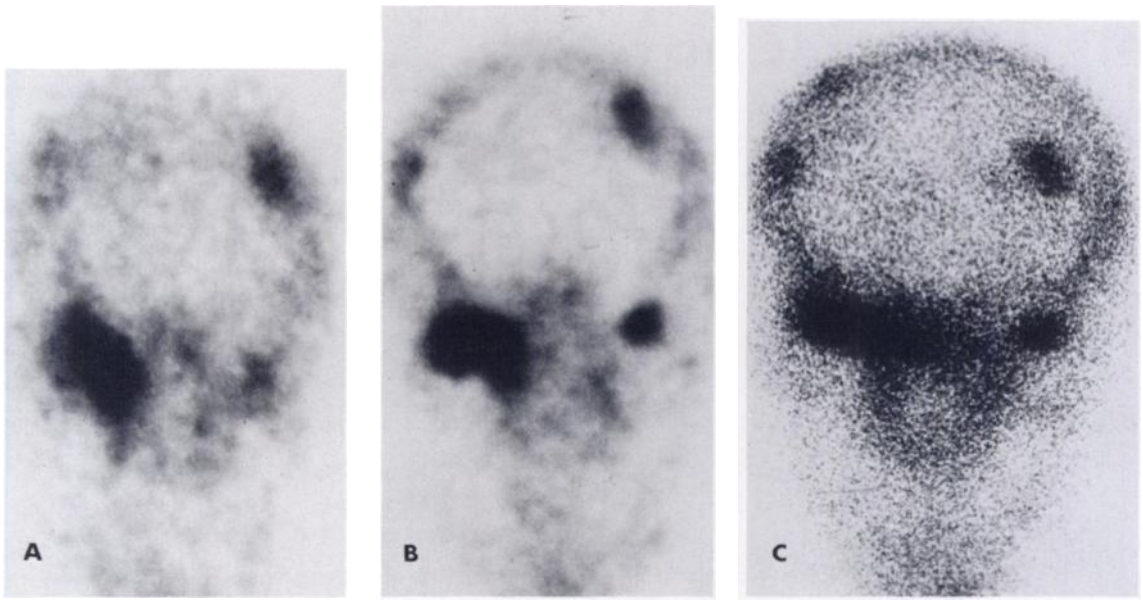

FIG. 6. (A) Anterior skull Cleon image performed in whole-body mode at 5 cm per minute. This is original technique we used with focal plane quite superficial in frontal bone. Although some of breast metastases are seen, much of calvarium appears out of focus. (B) Anterior Cleon in whole-body mode at 2.5 cm per minute. This scan, focused 3–4 cm behind the frontal bone, is made with our current technique. Metastases and calvarium are more clearly demonstrated. (C) Anterior Searle HP view with low-energy all-purpose collimator and 150,000 counts. Positioning is slightly different from that used for Cleon images performed the same day. Image quality is similar to that of 6B.

total-body scanning with technetium-99m phosphate compounds. Total-body studies, including four views of the skull, can be obtained in approximately 50 min with lesion detectability as good as with the scintillation camera in a static mode. Patient acceptance of the instrument is quite good, due to the rapidity with which the images can be made and to the quiet, nearly motion-free operation. The disc storage of data, with repeat views at will, is a highly desirable feature, avoiding the need to repeat images because of unsatisfactory technique, or desire for further display manipulation.