# Nonuniformity Intrinsic Flood Artifact Caused by Point-Source Syringe Needle

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The purpose of this study was to investigate the cause of a nonuniformity artifact seen on an intrinsic flood.
***Methods:*** Intrinsic floods were acquired on three different cameras using a point source in a 1-cc syringe, with and without a needle attached. Floods were obtained with the syringe placed perpendicular and parallel to the camera face.
***Results:*** A nonuniformity artifact was evident if a syringe with a needle was placed perpendicular to the crystal face.
***Conclusion:*** If a syringe is used as a point source during the acquisition of an intrinsic quality control flood, the needle should not be placed perpendicular to the camera face.
***Key Words:*** artifact; quality control; nonuniformity

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At one of our institutions, 3-million-count intrinsic floods were used for daily quality control of a triple-head SPECT camera system. Using a point-source configuration recommended by the camera manufacturer's applications section, these intrinsic floods give adequate information for evaluating the camera's uniformity (within non-NEMA specifications) on a daily basis (Fig. 1).

A refillable flood source is used to acquire 100-million-count extrinsic flood tables on a less frequent basis (every 2–3 wk for each type of collimator). These are used for uniformity corrections on all clinical studies as well as the daily intrinsic quality control floods.

The use of daily intrinsic floods was chosen over extrinsic floods because of the time savings and the lower radiation exposure to the staff when compared to the use of a refillable flood source (*1*). The cost is also much lower when compared to the purchase of a $^{57}$Co flood source.

During routine daily quality control, one head of the triple-head camera demonstrated nonuniformity (Fig. 2). The flood acquisitions were promptly repeated and the nonuniformity was no longer seen. This temporary appearance of a nonuniformity had been seen rarely in the past. The camera system had not had any recent uniformity problems. After a close review of the acquisition protocol, it was thought that the nonuniformity was an artifact. The purpose of this study was to determine if this artifact was caused by the position of the point-source syringe.

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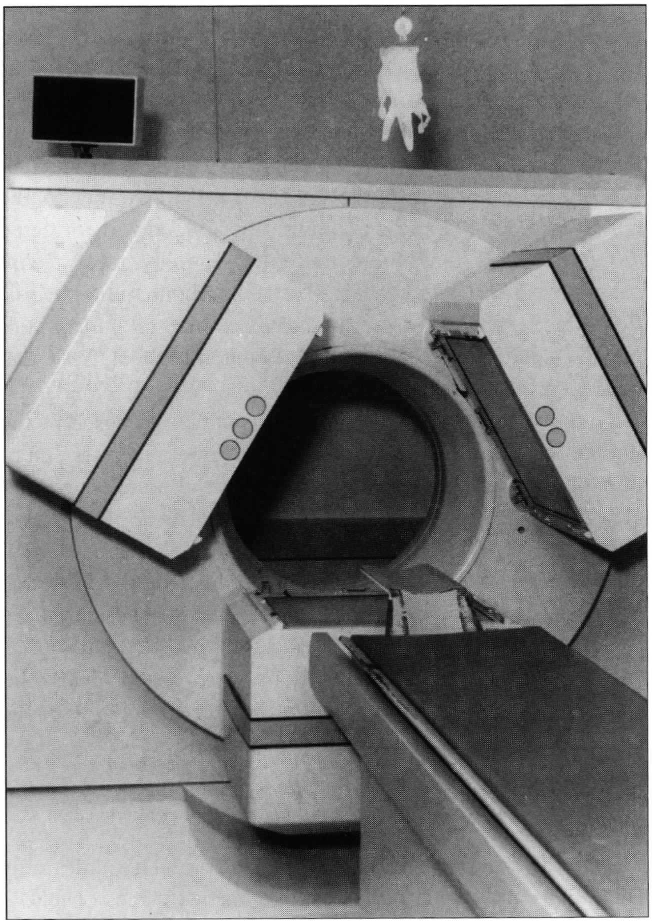

**FIGURE 1.** Triple-head camera setup used for daily intrinsic flood quality control. Point source in a 1-cc syringe with a 26-gauge needle is placed in a glove that is extended over the crystal face (2.4 FOVs) with the collimators removed and heads retracted.

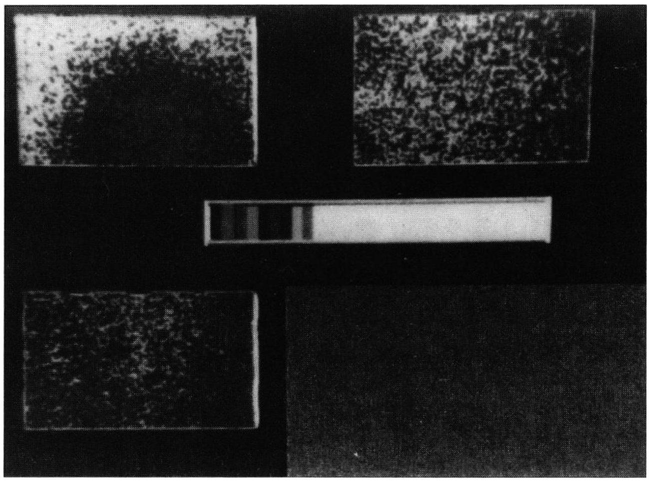

**FIGURE 2.** Initial intrinsic floods of a three-head camera that prompted this study. Note the nonuniformity seen in the top left flood. Note that these photographs were taken from a color image, therefore, yielding an improper gray scale.

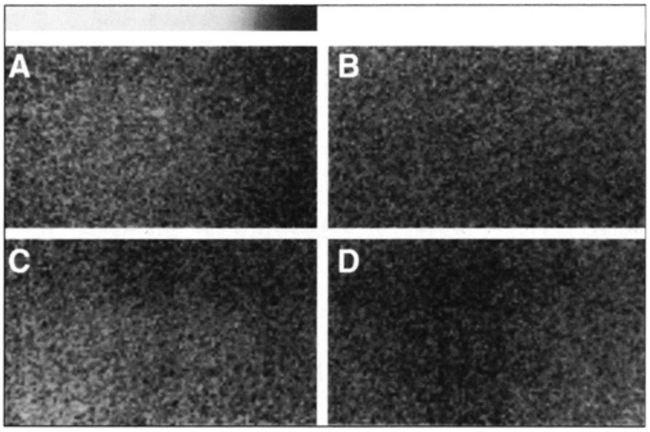


**FIGURE 3.** Intrinsic floods from a triple-head camera, corrected with an intrinsic flood table (top) or an extrinsic flood table (bottom), and with the point source in a syringe with a needle either (A,C) perpendicular or (B,D) parallel to the crystal face. Due to the difficulty in positioning the point source over the camera (e.g., not directly perpendicular, slight motion of source due to air vent), the artifact is not centered but is still evident.

## MATERIALS AND METHODS

Three-million-count intrinsic floods were obtained using a point source (<0.1 ml) of $^{99m}$Tc in a 1-cc tuberculin syringe with a 26-gauge needle attached. With all heads fully retracted and the collimators removed, the point source was centered over one of the system's heads at a distance of 3.7 fields of view (FOVs) away. Due to the height of the ceiling, this was the maximum distance that could be achieved. Floods were obtained with the point source positioned either perpendicular (needle pointing toward the crystal face) or parallel to the crystal face. Each 3-million-count intrinsic flood was corrected either with a 100-million-count intrinsic flood table (point source parallel to the crystal) or a 100-million-count extrinsic flood table (refillable sheet flood source). Integral uniformities were calculated for the useful and center FOV (UFOV and CFOV, respectively).

To test whether or not the nonuniformity was caused by the limited configuration of the triple-head camera (scatter and/or attenuation from the other heads and/or the point source not at least 5 FOVs away), 2-million-count intrinsic floods were acquired using similar techniques on two single-head scintillation cameras, one large and one small field of view (LFOV and SFOV). The source distances were at least 5 FOVs.

To determine if the artifact was caused by the point source, various syringe/needle combinations were tested. These included placement of activity within the syringe only versus the needle and removal of needle from the syringe.

## RESULTS

All three camera systems demonstrated visual nonuniformity (Figs. 3, 4) and increased integral uniformity values (Table 1) when a syringe with needle point source was positioned perpendicular to the crystal face. The artifact was always present when a needle was on the syringe, whether or not the radioactivity was in the needle. If the needle was removed and replaced with a plastic syringe cap, the nonuniformity artifact was no longer seen even if the syringe remained perpendicular to the crystal face.

## DISCUSSION

This study demonstrates that a nonuniformity intrinsic flood artifact can be caused by a point-source syringe needle that is positioned perpendicular to the crystal face. The artifact was rarely seen during our daily quality control procedure because the point source that was positioned over the camera was

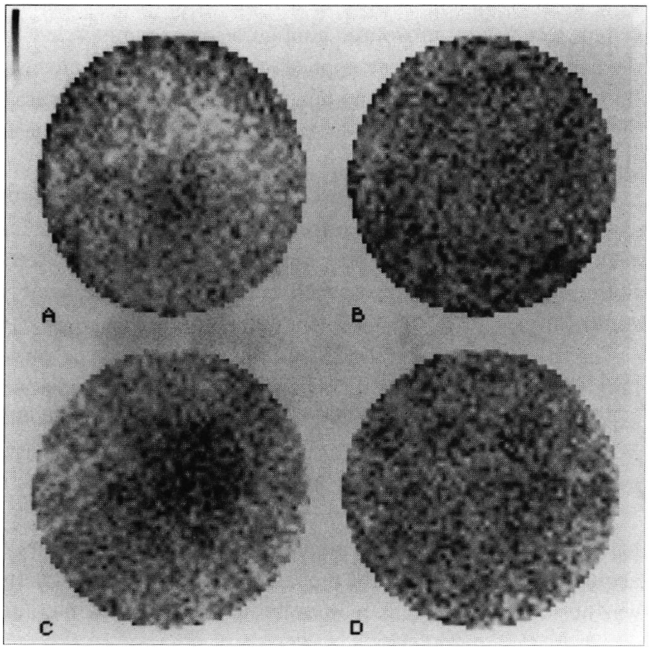


**FIGURE 4.** Intrinsic floods from two single-head cameras, LFOV (top) and SFOV (bottom), with the point source in a syringe with a needle either (A,C) perpendicular or (B,D) parallel to the crystal face.

**TABLE 1**
**UFOV/CFOV Integral Uniformity Values**

| Camera type | Position of point-source syringe compared to crystal face: Perpendicular UFOV/CFOV | Parallel UFOV/CFOV |
|---|---|---|
| One-head of Triple-head | | |
| Corrected with intrinsic flood table | 13.0%/9.5% | 8.6%/6.5% |
| Corrected with extrinsic flood table | 11.0%/9.0% | 9.4%/8.7% |
| LFOV single-head | 12.8%/7.5% | 8.4%/6.1% |
| SFOV single-head | 10.3%/9.4% | 6.6%/5.7% |

rarely perpendicular to the crystal face. When the artifact was seen, it was only seen on one head and, thus, not repeatable. When the heads rotated, the geometry was altered so the point source was no longer perpendicular to the camera face and, therefore, the artifact was no longer seen.

The use of a syringe as a point source is commonly used in daily camera quality control in nuclear medicine. Though we have used this type of point source on several different cameras over the years, due to the position of the syringe (e.g., on the floor, extended over the camera but not perpendicular to the crystal face), this artifact has been rarely seen, and was without an explanation when it was observed. We presented these findings and others have seen this type of artifact and have taken steps to prevent it (*2,3*). Some technologists and medical physicists did not think that a needle would cause such an evident nonuniformity artifact. This type of artifact can result in time and effort by the technologist to determine its cause. Due to the design of some cameras, intrinsic floods can only be performed with the point source placed over the crystal face. The position of the point source should be taken into consideration when performing daily quality control if a syringe with a needle is used. The needle can be removed to eliminate the artifact but it should be replaced with a syringe cap to avoid possible contamination. Other types of point sources can be used, plastic tubes or hard gelatin capsules but they will involve additional manipulation of the radioactivity (*3,4*).

In some of the older camera systems that require high-count intrinsic floods stored in the camera's uniformity correction module, this type of artifact has the potential to cause problems with clinical studies. If the camera's high-count uniformity data is obtained with the artifact present (needle perpendicular to the crystal face), the correction module will erroneously correct for the nonuniformity artifact (Fig. 5). The intrinsic flood taken immediately after, without the source being moved, will show a uniform flood, therefore, giving the impression that the camera can be used clinically. If the source is then placed parallel to the crystal face (giving a uniform distribution of photons), the flood appears to be nonuniform because of the erroneous correction. If this is not immediately observed by the technologist, it may affect clinical studies.

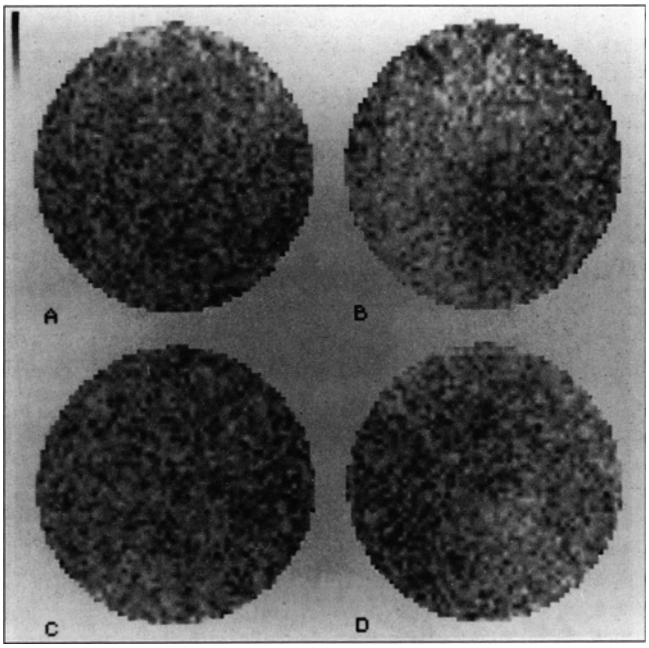


**FIGURE 5.** Intrinsic floods from a SFOV camera. (A) Initial uniform flood using a point source in syringe with a needle parallel to the crystal face. (B) Similar to previous figures, a nonuniformity artifact is seen when the point source is perpendicular to crystal face. (C) With the source in this position, the camera's uniformity module is updated and the immediate flood erroneously shows a uniform flood. (D) With the point source placed parallel (giving a uniform photon distribution), the flood appears to be nonuniform due to the uniformity update with the artifact present. Note that the artifacts seen in Figures 5B and D are reversed, in respect to count densities.

## CONCLUSION

A nonuniformity intrinsic flood artifact can be caused by the needle on a point-source syringe. Care should be taken when positioning a point source of this type so it is not perpendicular to the crystal face.

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