Effect of Crystal Thickness on Scintillation Camera Performance

During the last decade, the intrinsic resolution of scintillation cameras has improved from 12 mm full width at half maximum (FWHM) to approximately 4 mm FWHM, and system resolution has improved from 14 mm at 10 cm distance from the collimator to approximately 8 mm FWHM. This significant improvement was achieved not through major changes in technology, but through a series of refinements, each of which resulted in a small improvement of the overall performance. I use the word "small" not to belittle the individual contributions, but rather in the sense that the individual improvements did not make a dramatic change in the visual quality of clinical images. One such change that has been the subject of several recent publications (*1-3*) is the reduction in crystal thickness from 1/2 in. to 1/4 in. in small-field-of-view mobile cameras and from 1/2 in. to 3/8 in. in some large-field-of-view cameras.

These publications are not in complete agreement; however, it will serve the present purpose to assume as a conservative estimate that the reduction of crystal thickness from 1/2 in. to 1/4 in. in low-energy mobile cameras results in the changes in intrinsic resolution and sensitivity summarized in Table 1.

TABLE 1.

	Intrinsic resolution improvement*	Loss of sensitivity
Tl-201	≈1.3 mm FWHM	negligible
Tc-99m	≈1.0 mm FWHM	~15%

*The resolution improvement is stated in terms of millimeters FWHM changes for a line-spread function; bar-pattern resolution must be multiplied by 1.8 to give comparable numbers.

While the improvement in intrinsic resolution is significant, it is important to assess the influence of this change on system performance. Clearly, the improvement in system resolution at distances from 7 to 10 cm from the collimator will be less than 1.0 mm FWHM for Tc-99m and will not be perceived easily in bar-pattern images. It will be a useful exercise, however, to calculate system resolution for a 1/4 in. crystal camera with intrinsic resolution of R_I = 4 mm and a high-resolution collimator and compare it to a 1/2 in. crystal camera with R_I = 5mm and a high-resolution collimator that has 15% lower sensitivity and correspondingly higher resolution. In other words, there are two methods to improve resolution at a sacrifice in sensitivity: (a) reduce crystal thickness, or (b) change the collimator. These two cases are summarized in Table 2.

Thus, for Tc-99m imaging, either approach will produce nearly equivalent results at clinically significant distances from the collimator. For imaging of Tl-201, however, the loss in sensitivity is negligible, and the improved intrinsic resolution results in an improvement in system performance (Table 3).

TABLE 2. TECHNETIUM-99m.

	Distance from collimator	R_I = 4.0 mm FWHM 1/4 in. crystal high-resolution collimator	R_I = 5.0 mm FWHM 1/2 in. crystal hypothetical high-resolution collimator
	0 cm	4.3 mm	5.2 mm
System resolution	5 cm	5.7 mm	6.2 mm
	10 cm	7.6 mm	7.7 mm
	15 cm	9.7 mm	9.5 mm
Relative sensitivity		0.85	0.85

TABLE 3. THALLIUM-201.

	Distance from collimator	High resolution collimator R_I = 5.3 mm FWHM 1/4 in. crystal	High resolution collimator R_I = 6.6 mm FWHM 1/2 in. crystal
	0 cm	5.5 mm	6.8 mm
System resolution	5 cm	6.6 mm	7.7 mm
	10 cm	8.3 mm	9.2 mm
	15 cm	10.3 mm	11.0 mm
Relative sensitivity		1.0	1.0

The improvement indicated in Table 3 is indeed significant as has been demonstrated by various authors (*1–3*).

The reason for the improved intrinsic spatial resolution with a thinner crystal is not as obvious as it appears at first glance. It is a popular misconception (*3*) that the improvement is due to the fact that the photomultipliers are in closer proximity to the origin of the light in a 1/4 in. crystal than in a 1/2 in. crystal. If this were the case, the same result could be achieved by reducing the thickness of the glass covering the crystal by 1/4 in. This reduction in glass thickness, however, does not achieve the desired result. A more probable reason is that the reduced crystal thickness changes the light distribution at the photomultipliers because of the index of refraction change at the crystal-to-glass interface and because of additional design freedom in positioning optical masks between the crystal assembly and the lightpipe.

In summary, the reduction in crystal thickness from 1/2 in. to 1/4 in. represents a reasonable trade-off — increased resolution for a small loss of sensitivity for imaging with Tc-99m and a significant improvement in system resolution at a negligible loss in sensitivity for imaging with Tl-201.

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REFERENCES

1. SANO RM, TINKEL JB, LAVALLEE CA, et al: Consequences of crystal thickness reduction on gamma camera resolution and sensitivity. *J Nucl Med* 19:712–713, 1978
2. CHAPMAN D, NEWCOMER K, BERMAN D, et al: Half-inch vs. quarter-inch Anger camera technology: resolution and sensitivity differences at low photopeak energies. *J Nucl Med* 20:610–611, 1979
3. ROYAL HD, BROWN PH, CLAUNCH BC: Effects of a reduction in crystal thickness on Anger camera performance. *J Nucl Med* 20:977–980, 1979

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