The criticism that the authors are really making is whether the quadrant phantom is useful for measuring intrinsic resolution; bar phantoms, in general, are useful for giving a quick assessment of spatial resolution.

If it is assumed that the relationship we found between bar spacing and FWHM holds down to the size of bars used in this particular quadrant phantom, then the 3-mm bars would only fail to be seen if the FWHM exceeded 5.9 mm. In other words, for the intrinsic resolution measurements made in the reported experiment only the 2- and 2.5-mm-wide bars are of value. Clearly the design of the quadrant bar phantom is not satisfactory.

The advantage of the line resolution pattern (LRP) over a bar pattern is that as FWHM is equal to minimum resolvable line separation then a quantitative measure of spatial resolution can be made easily. If that is indeed the case, and one is always concerned that other factors such as the way in which the image is displayed might have an effect, then the LRP would be useful for centers that do not have access to data processing facilities.

The place of such measurements of intrinsic spatial resolution in a regular quality control procedure should be addressed rather more closely than has been done by O'Connor and Oswald. As changes in intrinsic resolution are likely to be local, the LRP is not going to be an effective way of detecting them. The small size of the phantom and the even smaller area over which measurements are made, make measurements of resolution at many points in the camera's field of view impractical. Indeed there may be a case for making the pattern larger and the lines longer, although it will then be heavier than a similar size of bar phantom.

In our experience the flood images is probably the most useful Q.C. measurement and while the cause of nonuniformaties may be nonspecific, including changes in intrinsic resolution, it can provide a simple, sensitive and global measure of detector performance (*4*).

References

1. O'Connor MK, Oswald WM. The line resolution pattern: a new intrinsic resolution test pattern for nuclear medicine. *J Nucl Med* 1988; 29:1856–1859.
2. Kasal B, Sharp PF. Gamma camera spatial resolution as measured by the bar phantom. *Phys Med Biol* 1985; 30:263–266.
3. Paras P, Hine GJ, Adams R. Latest developments in gamma-camera performance testing: resolution measurements. In: Raynaud C, ed. *Nuclear medicine and biology.* Paris: Pergamon Press, 1982: 2890–2894.
4. Hughes A, Sharp PF. Factors affecting gamma-camera non-uniformity. *Phys Med Biol* 1988; 33:259–269.

P.F. Sharp
University of Aberdeen
Foresterhill, Aberdeen
Scotland

REPLY: We read with interest the paper of Kasal and Sharp (*1*) and noted the excellent correlation they obtained between gamma camera resolution as measured by the full width at half maximum (FWHM) and the minimum resolvable bar width of a bar phantom. While these results appear at odds with those obtained in our paper (*2*), a closer examination of both papers shows no discrepancy. The study of Kasal and Sharp was performed extrinsically with varying thickness of scattering medium (5–20 cm) placed between the collimator and the bar pattern. They evaluated resolution over a range of FWHM of 8–18 mm. Their equation, quoted above, indicates that a change of ~3 mm in extrinsic FWHM is required before there is a discernible change (>1 mm) in the minimum resolvable bar width. In our opinion, this insensitivity to changes in system FWHM is unacceptably large. Intrinsically we found a smaller but similar insensitivity of the bar pattern to changes in resolution. Thus while the bar pattern is adequate for very coarse measurements of extrinsic resolution, it is clearly unsuitable for the detection of smaller (<2 mm) but highly significant changes in intrinsic resolution.

With regard to their comments vis-a-vis the design of the line resolution pattern (LRP), we would like to point out that the LRP is not a bar phantom. It was designed to take advantage of the fact that two Gaussian profiles can only be resolved if they are separated by a distance greater than their FWHM. To achieve such profiles, the slit width of the LRP was set to 0.5 mm, which effectively makes it mathematically equivalent to an infintely narrow slit when compared with the FWHM of modern gamma cameras (>3 mm). Hence, with regard to the LRP, the equation and comments of Kasal and Sharp are not applicable.

As we stated in our paper, the main disadvantage of the LRP is that it only measures resolution over a small portion of the field of view. However, we believe that one quantitative measurement of resolution over a limited area is better than an insensitive measurement technique over the entire detector area. As to the place of measurement of intrinsic resolution in routine quality control, we would agree with Dr. Sharp that measurement of uniformity is clearly the most sensitive indicator of detector performance. In our Institution, measurement of intrinsic resolution has been relegated to third place after measurement of image uniformity and image linearity as a useful indicator of gamma camera performance.

References

1. Kasal B, Sharp PF. Gamma camera spatial resolution as measured by the bar phantom. *Phys Med Biol* 1985; 30:263–266.
2. O'Connor MK, Oswald WM. The line resolution pattern: a new intrinsic resolution test pattern for nuclear medicine. *J Nucl Med* 1988; 29:1856–1859.

Michael K. O'Connor
William M. Oswald
Mayo Clinic
Rochester, Minnesota