Perry J. Pickhardt, MD
Andrew D. Lee, MD
Elizabeth G. McFarland, MD
Andrew J. Taylor, MD

Published online
10.1148/radiol.2363041534
Radiology 2005; 236:872–878

Abbreviations:
MPR = multiplanar reformation
3D = three-dimensional
2D = two-dimensional

[1] From the Department of Radiology, University of Wisconsin Medical School, E3/311 Clinical Science Center, 600 Highland Ave, Madison, WI 53792-3252 (P.J.P., A.D.L., A.J.T.); Department of Radiology and Nuclear Medicine, Uniformed Services University of the Health Sciences, Bethesda, Md (P.J.P.); Diagnostic Imaging Associates, St Luke's Hospital, Chesterfield, Mo (E.G.M.); and Mallinckrodt Institute of Radiology, Washington University School of Medicine, St Louis, Mo (E.G.M.). Received September 6, 2004; revision requested November 12; revision received December 13; accepted January 12, 2005. **Address correspondence to** P.J.P. (e-mail: *pj.pickhardt@hosp.wisc.edu*).

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See Materials and Methods for pertinent disclosures.

Author contributions:
Guarantor of integrity of entire study, P.J.P.; study concepts/study design or data acquisition or data analysis/interpretation, all authors; manuscript drafting or manuscript revision for important intellectual content, all authors; approval of final version of submitted manuscript, all authors; literature research, P.J.P., A.D.L.; clinical studies, P.J.P., E.G.M.; experimental studies, P.J.P., A.D.L.; statistical analysis, P.J.P., A.D.L.; and manuscript editing, P.J.P., E.G.M., A.J.T.

Linear Polyp Measurement at CT Colonography: In Vitro and in Vivo Comparison of Two-dimensional and Three-dimensional Displays[1]

PURPOSE: To compare the accuracy of polyp measurement at computed tomographic (CT) colonography by using two-dimensional (2D) multiplanar reformation (MPR) and three-dimensional (3D) endoluminal displays obtained both in a colon phantom and at clinical examinations.

MATERIALS AND METHODS: This HIPAA-compliant study had institutional review board approval, and all patients provided signed informed consent, both of which allowed for additional retrospective evaluation. Two-dimensional and 3D CT colonography displays were generated from data obtained in an in vitro colon phantom that contained 10 6–13-mm synthetic polyps and from data obtained at in vivo clinical CT colonography examinations performed in 10 patients (five men, five women; mean age, 56.3 years) with proved polyps (size range, 7–25 mm). The reference standard for in vivo polyp size was optical colonoscopic measurement with a calibrated linear probe. Polyps were measured at CT colonography with 2D MPR and 3D endoluminal displays and electronic calipers by four radiologists who were unaware of the reference size measurements. The largest of the three 2D MPR measurements was considered the "optimized" 2D projection. Statistical analysis was performed with Wilcoxon signed rank, repeated-measures analysis of variance, and paired *t* testing.

RESULTS: For the phantom, the mean errors (differences between actual polyp size and that measured at CT colonography) for 2D transverse, 2D coronal, and 3D endoluminal displays were 1.6 mm ± 0.8 (standard deviation), 1.4 mm ± 0.7, and 0.8 mm ± 0.5, respectively. For in vivo polyp measurements, the mean errors for 2D transverse, 2D coronal, 2D sagittal, and 3D displays were 4.4 mm ± 3.5, 3.8 mm ± 3.3, 4.6 mm ± 3.0, and 1.9 mm ± 1.6, respectively. The 2D measurements underestimated actual polyp sizes in all cases. The differences in mean errors between 2D MPR and 3D endoluminal measurements were significant ($P < .05$). When the optimized 2D view was considered for in vivo measurement, the mean error decreased to 3.0 mm ± 2.6 ($P = .2$).

CONCLUSION: Linear polyp measurement on 3D endoluminal views was significantly more accurate than measurement on 2D transverse, coronal, or sagittal views, both in vitro and in vivo, for the CT colonography system evaluated. Use of the optimized 2D view substantially reduced 2D measurement error and may be valuable when used in conjunction with 3D measurement.

Lesion size is perhaps the single most important feature of a polyp detected at computed tomographic (CT) colonography because it serves as a rough surrogate for histologic features and therefore dictates both the clinical importance of the polyp and patient care (1–4). In nearly all CT colonography–based studies to date (5–13), as well as in routine

clinical practice, the two-dimensional (2D) display has been used for polyp size estimation, with most investigators presumably relying on the transverse view. Although some experts have recommended that all three standard orthogonal planes from the 2D multiplanar reformations (MPRs) be used for determining the largest or "optimized" 2D polyp diameter (1–3), most published articles have not specified whether this was done in their Methods sections. Despite this reliance on 2D polyp measurement, we are not aware of published results that confirm the accuracy of this approach. Although the three-dimensional (3D) endoluminal display is also unproved, it offers the potential for more accurate measurement because the vantage point for maximizing polyp dimension can be readily optimized, unlike with standard 2D MPR views, which can lead to underestimation of obliquely oriented polyps. Thus, the purpose of our study was to compare the accuracy of polyp measurement with 2D MPR and 3D endoluminal displays in both a colon phantom and at clinical CT colonography examinations.

MATERIALS AND METHODS

Colon Phantom

A colon phantom for the simulation of luminal polyps was constructed out of polymethyl methacrylate (14). The air-filled sealed cylinder (length, 230 mm; wall thickness, 8 mm; inner diameter, 38 mm) was immersed in a liquid-filled box to achieve an attenuation and a signal-to-noise ratio that were comparable to those seen clinically (14). CT image acquisition for the phantom was performed with a 16–detector row scanner (Sensation 16; Siemens Medical Systems, Iselin, NJ), with 120 kVp, 100 mAs, a 3-mm effective section thickness, and a 1-mm reconstruction interval. The long axis of the cylinder was placed at 45° relative to the z-axis of the scanner.

Four acrylic spheres were attached to the inner surface of the cylinder to simulate pedunculated polyps, and six synthetic sessile polyps were simulated by using the previously described "sunken sphere" method (14). The reference standard for in vitro polyp size was direct measurements obtained by using a combination of calipers and bore gauges. The 10 synthetic polyps used in this study ranged in size from 6 to 13 mm (mean, 9.4 mm) and were arranged in two uniform rows (Fig 1). The sessile polyps were relatively flat lesions that varied in height from 1 to 3 mm. Flat polyps represent a subset of sessile polyps and are herein defined as relatively shallow plaquelike lesions with a height that is less than half their width (15). In general, assessment of polyp morphologic features is somewhat subjective.

Clinical CT Colonography Cases

The in vivo study set for 2D and 3D measurements comprised 10 colorectal polyps at CT colonography performed in 10 patients (five men, five women; age range, 50–64 years; mean age, 56.3 years) who met the selection criteria described later in this section. CT colonography was approved by the institutional review board, and all patients provided signed informed consent. Both the institutional review board approval and the informed consent allowed additional retrospective evaluation. Our study was compliant with the Health Insurance Portability and Accountability Act. P.J.P. serves as medical advisor to Viatronix, Stony Brook, NY.

Colon catharsis for these studies was achieved with sodium phosphate administered the day before examination. Colonic distention was achieved with patient-controlled insufflation of room air. The clinical CT colonography examinations were performed with four–detector row scanners (GE LightSpeed Plus; GE Medical Systems, Milwaukee, Wis) and a technique similar to that used in the phantom study: 120 kVp, 100 mAs, a 3-mm effective section thickness, a 1-mm reconstruction interval, 0.5 second per gantry rotation, and a table speed of 15 mm/sec (high-speed mode).

Criteria for clinical polyp inclusion were as follows: a size of 6 mm or greater, location within a well-distended air-filled portion of the colon at supine CT colonography, an unambiguous match at optical colonoscopy, and an available histopathologic diagnosis. All polyps were confirmed, measured, and subsequently removed at optical colonoscopy performed immediately after CT colonography. The reference standard for in vivo polyp size was real-time endoscopic measurement performed by using a calibrated linear probe; this method of measurement is more accurate than visual estimation, open biopsy forceps estimation, or ex vivo measurement (16). The 10 polyps ranged in size from 7 to 25 mm (mean, 13.7 mm) and were located in the rectum (n = 3), sigmoid colon (n = 2), descending colon (n = 1), splenic flexure (n = 1), hepatic flexure (n = 1), ascending colon (n = 1), or cecum (n = 1). Subjective assessment of polyp morphologic features revealed five sessile lesions, four pedunculated lesions, and one flat lesion; this distribution reflects the relative order of frequency seen in clinical practice. Histologic diagnoses at pathologic evaluation were tubular adenoma (n = 6) and tubulovillous adenoma (n = 4).

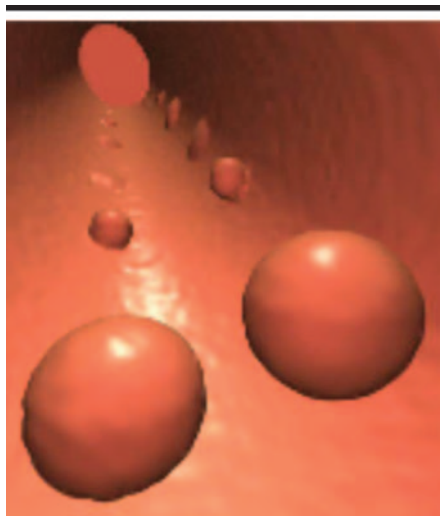

Figure 1. Three-dimensional endoluminal view from CT colonography of colon phantom shows the 10 synthetic polyps arranged in two uniform rows.

Two-dimensional and 3D Polyp Measurement at CT Colonography

Four board-certified radiologists (including A.J.T.) with an interest in abdominal imaging (range of experience, 5–25 years) each measured the in vitro and in vivo polyps independently with no knowledge of the reference-standard size measurements. The 2D MPR and 3D endoluminal measurements were performed with a commercially available CT colonography evaluation system (V3D Colon, version 1.2; Viatronix). For standardization, the supine data set was used for polyp measurement in all cases. The 2D MPR measurements were obtained with electronic calipers by using the "polyp" window standard to the CT colonography system used (window width, 2000 HU; window level, 0 HU), with mandatory zoom magnification. The 3D endoluminal measurements were also obtained with electronic calipers. The CT colonography system used for this study allowed manual navigation for optimizing the endoluminal vantage point and the placement of caliper points in 3D space. All readers were trained in

TABLE 1
Pooled 2D and 3D Measurements of in Vitro Polyps in Phantom

Polyp No.	Actual Size (mm)	2D Transverse Display		2D Coronal Display		3D Endoluminal Display	
		Mean Size (mm)	Error (mm)*	Mean Size (mm)	Error (mm)†	Mean Size (mm)	Error (mm)‡
1	6.0	4.8 ± 0.7	1.2	5.0 ± 0.8	1.0	5.6 ± 1.1	0.4
2	6.0	4.4 ± 0.8	1.6	5.2 ± 0.8	0.8	6.3 ± 1.5	0.3
3	11.0	8.7 ± 0.7	2.3	8.8 ± 0.7	2.2	9.7 ± 1.0	1.3
4	11.0	8.0 ± 0.9	3.0	8.3 ± 0.5	2.7	10.1 ± 1.6	0.9
5	11.0	9.0 ± 0.7	2.0	9.2 ± 0.7	1.8	9.9 ± 0.8	1.1
6	11.0	9.2 ± 0.9	1.8	9.2 ± 1.9	1.8	10.2 ± 1.7	0.8
7	6.0	5.5 ± 0.3	0.5	5.2 ± 0.6	0.8	7.0 ± 0.7	1.0
8	6.0	5.0 ± 0.4	1.0	5.2 ± 0.4	0.8	7.7 ± 1.3	1.7
9	13.0	12.0 ± 0.3	1.0	11.7 ± 0.2	1.3	12.7 ± 0.9	0.3
10	13.0	11.9 ± 0.4	1.1	11.9 ± 0.5	1.1	13.4 ± 1.2	0.4

Note.—Mean size (± standard deviation) represents the pooled measurement from the four readers, and error refers to difference between actual size and measured size.
* Mean error = 1.6 mm ± 0.8.
† Mean error = 1.4 mm ± 0.7.
‡ Mean error = 0.8 mm ± 0.5.

the proper use of caliper placement, and care was particularly taken not to "fall off" the edge of a polyp on 3D views, which would lead to inappropriate measurement of a more distant point on the colonic wall. For both 2D and 3D displays, the readers were instructed to obtain measurements along the longest available linear dimension but to avoid including the stalks of pedunculated lesions.

The 10 in vitro phantom polyps were measured on 2D transverse, 2D coronal, and 3D endoluminal displays (Fig 1). Separate measurements were not obtained for the 2D sagittal view because it was symmetric to the transverse view and therefore redundant for this particular phantom. Each of the four readers measured all 10 synthetic polyps on the three different displays, resulting in a total of 120 measurements. The 10 in vivo clinical polyps were measured on 2D transverse, 2D coronal, 2D sagittal, and 3D endoluminal displays, resulting in a total of 160 measurements. For each clinical case, the readers also indicated which of the three orthogonal 2D MPR views subjectively enabled the best size estimate. In addition, the longest measurement obtained among the transverse, coronal, and sagittal displays for each case was considered the "optimized" 2D MPR measurement.

Statistical Analysis

Statistical analysis was performed by using the Wilcoxon signed rank test, as well as a repeated-measures analysis of variance followed by paired *t* testing, to compare differences in the errors between the various 2D MPR and 3D endoluminal polyp size measurements. The mean error, which consisted of the difference in size between individual reader measurements at CT colonography and the reference-standard measurement, was calculated from the absolute values of the errors for individual polyps. A *P* value of less than .05 was considered to indicate a statistically significant difference.

RESULTS

Polyp Measurement with in Vitro Colon Phantom

The error in linear measurement, defined as the difference between the actual and the CT colonography–measured polyp diameter, was greater with the 2D displays than with the 3D endoluminal display ($P < .05$) (Table 1, Fig 2). Specifically, the pooled errors between the actual and the CT colonography–measured polyp sizes were 1.6 mm ± 0.8 (standard deviation), 1.4 mm ± 0.7, and 0.8 mm ± 0.5 for the 2D transverse, 2D coronal, and 3D endoluminal displays, respectively. Because the synthetic polyps all had rounded, symmetric features, optimization among the 2D MPR views was less applicable; this fact was further supported by the close agreement between the 2D transverse and 2D coronal measurements.

The 2D MPR views led to an underestimation of actual polyp size for 78 (98%) of the 80 individual measurements, whereas 23 (58%) of the 40 individual 3D measurements were lower than the actual size. This was also reflected in the pooled data, in which all 20 of the mean 2D measurements were less than the actual polyp size and six of the 10 mean 3D measurements underestimated the actual size.

Polyp Measurement with in Vivo CT Colonography Cases

As seen with the colon phantom, the error in CT colonography measurement (relative to the endoscopic reference-standard measurement) was again greater with the individual 2D MPR displays than with the 3D endoluminal view ($P < .05$) (Fig 3). Specifically, the pooled errors for the 2D transverse, 2D coronal, 2D sagittal, and 3D endoluminal displays were 4.4 mm ± 3.5, 3.8 mm ± 3.3, 4.6 mm ± 3.0, and 1.9 mm ± 1.6, respectively (Table 2). Two-dimensional MPR and 3D endoluminal CT colonography projections for a representative oblong polyp are depicted in Figure 4.

When the optimized 2D measurement was considered as a separate category, the mean error was 3.0 mm ± 2.6. Although still greater than the error seen with 3D measurement, this difference was not statistically significant ($P = .2$). Mean polyp measurement was optimal (ie, yielded the largest values) with the 2D coronal projection in five cases, with the sagittal projection in four cases, and with the transverse display in only one case. When readers were asked to select which 2D MPR view they felt was best for measuring each in vivo polyp, the coronal projection was selected in 17 instances, while the sagittal projection was selected in 13 instances and the transverse projection was selected in 10. All four readers agreed on the same preferred 2D MPR view for only two of the 10 cases. Fur-

thermore, this subjective "best" 2D view corresponded to the largest 2D measurement for that individual reader in 33 (82%) of 40 instances, indicating that there were seven instances in which the preferred projection did not correspond to the projection with which the largest (optimized) 2D measurement was obtained.

The 2D MPR views led to an underestimation of the polyp size at optical colonoscopy for 110 (92%) of 120 individual 2D measurements. The 3D measurement was less than the endoscopic measurement in 28 (70%) of 40 individual measurements, but the degree of underestimation was typically less than that seen with the 2D measurements (Fig 3).

DISCUSSION

The size of the largest detected colorectal lesion that is reported after a screening CT colonography examination is a critical value because it largely determines subsequent patient care (4). The main reason for this is that polyp size serves as a surrogate for polyp histologic features and, by extension, the presumed clinical importance of the polyp. Therefore, accurate polyp size estimation at CT colonography is critical and was our motivation for comparing the accuracy of polyp measurement with 2D MPR and 3D endoluminal views.

The majority of clinical CT colonography–based studies to date have primarily involved the use of 2D measurements for polyp size estimation (5–13). Most investigators did not specify whether the largest (optimized) 2D MPR measurement was routinely obtained, but it appears that the acquisition of 2D transverse measurements was the standard in some (if not most) of these studies. By comparison, only one large study to date, to our knowledge, has involved using the 3D endoluminal view for primary polyp measurement (17). Although it has been assumed that measurements of polyps on 2D magnified views are accurate (1), we are not aware of published studies whose results confirm this. Similarly, we are not aware of studies in which the accuracy of polyp measurement on 3D endoluminal views was evaluated. At the very least, minimum guidelines for polyp size estimation at CT colonography need to be established to ensure reasonably uniform interpretation and reporting of data.

Our results show that 2D measurements resulted in systematic underestimations of polyp size and were less accu-

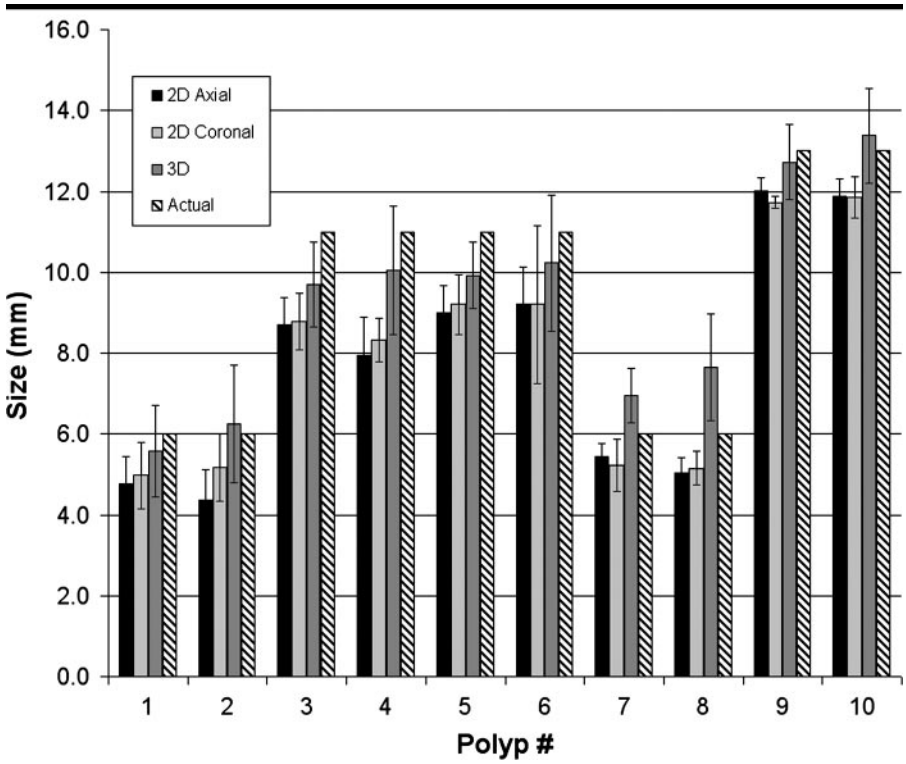

Figure 2. Bar graph shows pooled measurements (by the four readers) of the synthetic phantom polyps compared with the polyp sizes at optical colonoscopy. Error bars indicate 1 standard deviation. Note how 2D measurements consistently reflect an underestimation of polyp size.

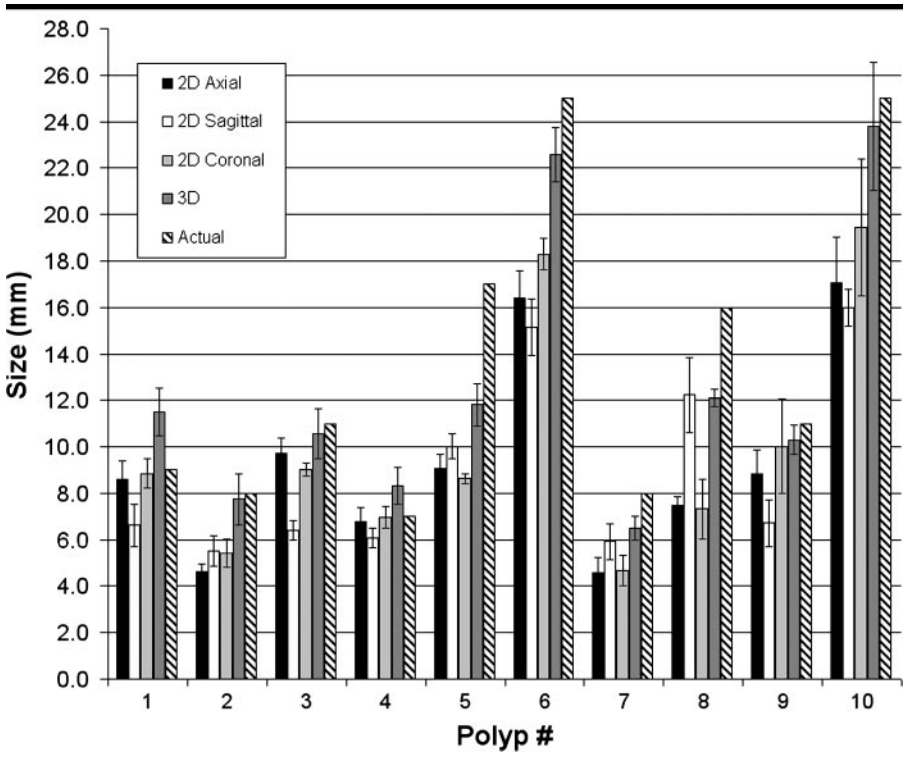

Figure 3. Bar graph shows pooled measurements (by the four readers) of the clinical polyps compared with the actual polyp sizes. Error bars indicate 1 standard deviation. Note again how 2D measurements consistently reflect an underestimation of polyp size, especially for larger lesions.

TABLE 2
Pooled 2D and 3D Measurements of in Vivo Polyps in Clinical CT Colonography Cases

Polyp No.*	Actual Size (mm)	2D Transverse Display		2D Coronal Display		2D Sagittal Display		2D Optimized Display		3D Endoluminal Display	
		Mean Size (mm)	Error (mm)†	Mean Size (mm)	Error (mm)‡	Mean Size (mm)	Error (mm)§	Mean Size (mm)	Error (mm)‖	Mean Size (mm)	Error (mm)#
1	9.0	8.6 ± 0.8	0.4	8.8 ± 0.6	0.2	6.6 ± 0.9	2.4	8.8 ± 0.6	0.2	11.5 ± 1.0	2.5
2	8.0	4.7 ± 0.3	3.3	5.4 ± 0.6	2.6	5.5 ± 0.7	2.5	5.5 ± 0.7	2.5	7.8 ± 1.1	0.2
3	11.0	9.7 ± 0.6	1.3	9.0 ± 0.3	2.0	6.4 ± 0.4	4.6	9.7 ± 0.6	1.3	10.6 ± 1.1	0.4
4	7.0	6.8 ± 0.6	0.2	7.0 ± 0.5	0	6.1 ± 0.4	0.9	7.0 ± 0.5	0	8.3 ± 0.8	1.3
5	17.0	9.1 ± 0.6	7.9	8.6 ± 0.2	8.4	10.0 ± 0.5	7.0	10.0 ± 0.5	7.0	11.8 ± 0.9	5.2
6	25.0	16.4 ± 1.2	8.6	18.3 ± 0.7	6.7	15.2 ± 1.2	9.8	18.3 ± 0.7	6.7	22.6 ± 1.2	2.4
7	8.0	4.6 ± 0.7	3.4	4.7 ± 0.7	3.3	5.9 ± 0.8	2.1	5.9 ± 0.8	2.1	6.5 ± 0.5	1.5
8	16.0	7.5 ± 0.4	8.5	7.3 ± 1.3	8.7	12.2 ± 1.6	3.8	12.2 ± 1.6	3.8	12.1 ± 0.4	3.9
9	11.0	8.8 ± 1.0	2.2	10.0 ± 2.0	1.0	6.7 ± 1.0	4.3	10.0 ± 2.0	1.0	10.3 ± 0.6	0.7
10	25.0	17.1 ± 1.9	7.9	19.5 ± 3.0	5.5	16.0 ± 0.8	9.0	19.5 ± 3.0	5.5	23.8 ± 2.8	1.2

Note.—Actual size refers to endoscopic measurement with calibrated linear probe (estimated to nearest millimeter), while mean size (± standard deviation) represents pooled measurements from the four readers, and error refers to difference between actual size and measured size.

* Polyps 2, 6, 7, 8, and 10 were sessile; polyps 1, 3, 5, and 9 were pedunculated; and polyp 4 was flat.

† Mean error = 4.4 mm ± 3.5.

‡ Mean error = 3.8 mm ± 3.3.

§ Mean error = 4.6 mm ± 3.0.

‖ Mean error = 3.0 mm ± 2.6.

Mean error = 1.9 mm ± 1.6.

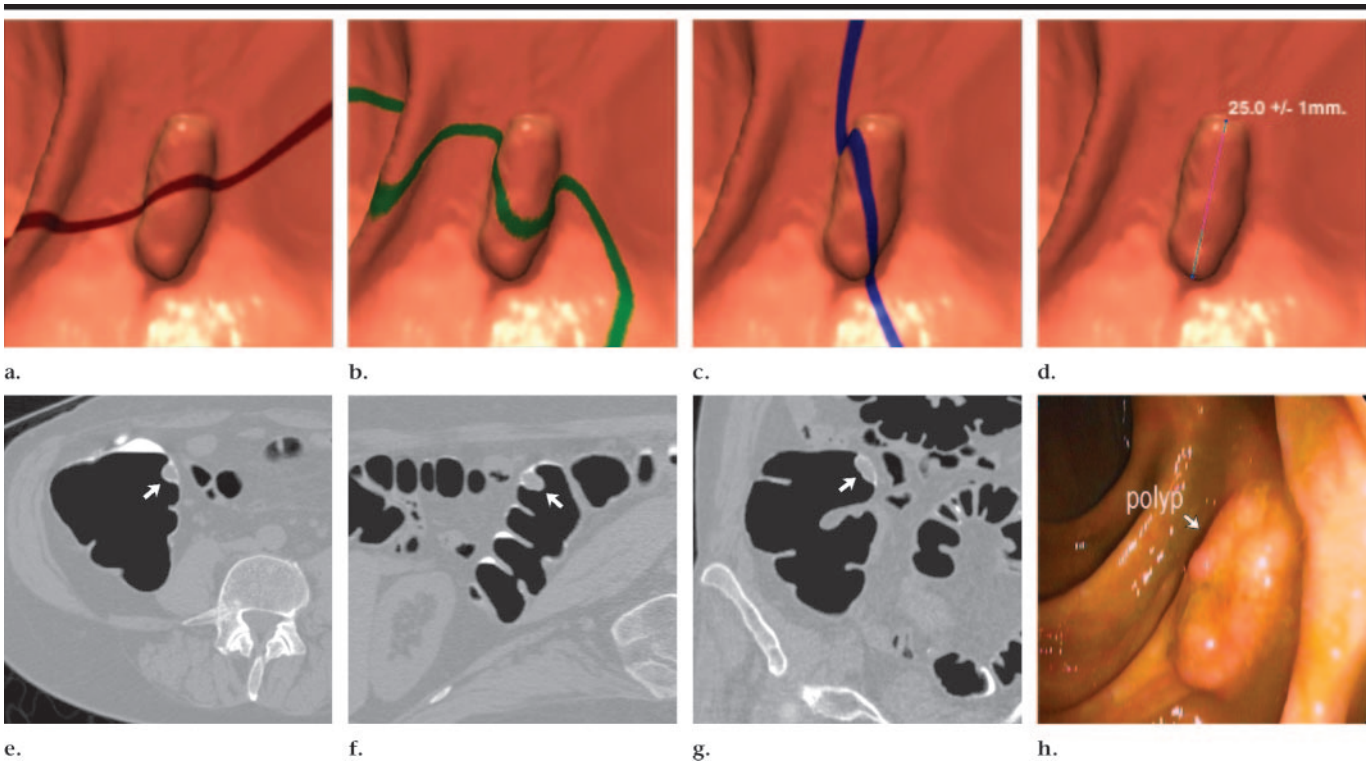

Figure 4. Tubular adenoma in ascending colon in asymptomatic 63-year-old woman who underwent colorectal screening. **(a–d)** 3D endoluminal views from CT colonography show the corresponding 2D transverse (red line), sagittal (green line), and coronal (blue line) planes. Note how all three 2D planes "miss" the long axis of this elongated polyp to varying degrees, resulting in gross undersizing of the lesion. On 3D views, measurement of the polyp's long axis (calipers in **d**) is straightforward. **(e–g)** 2D MPR images with "polyp" windowing (window width, 2000 HU; window level, 0 HU) show the polyp (arrow) in transverse (**e**), sagittal (**f**), and coronal (**g**) projections. From **c** and **g**, it can be seen that the coronal projection represents the "optimized" 2D MPR view. Coronal measurement, however, still results in gross underestimation of polyp size. **(h)** Digital photograph from optical colonoscopy performed the same day as CT colonography shows the lesion (arrow).

rate overall than 3D measurements for the CT colonography system we evaluated. This discrepancy between 2D and 3D measurements can be substantially reduced by optimizing the 2D MPR measurement, underscoring the importance of optimizing 2D measurement. Size underestimation on 2D views appears to stem primarily from two main factors.

For one, apparent shortening is expected (and often unavoidable) with the asymmetric polyps encountered in vivo because the standard orthogonal MPR planes are typically not aligned to the long axis of the polyp. This factor is independent of the specific CT colonography technique used, assuming the standard orthogonal 2D planes are employed. However, the fact that underestimation on 2D views was also seen with symmetrically rounded polyps in vitro in the present study indicates that additional factors exist.

Although this factor was not independently evaluated in this study, the second major factor appears to be the window width and level used for 2D visualization, which can result in apparent size diminution. This effect can be further exaggerated with soft-tissue windows but can be reversed by widening the window width and/or lowering the center level. This issue deserves further investigation. However, use of the 3D rendering technique with the CT colonography system we evaluated not only appeared to minimize this effect but also may have actually led to slight overestimation of size in some cases. The potential for size overestimation on 3D views needs to be considered, particularly for lesions near a critical size threshold. In such cases the use of both 3D and optimized 2D MPR displays seems to be the most prudent approach. Improved spatial resolution resulting from the use of even thinner section collimation could perhaps also result in improved polyp measurement. In some of our clinical cases (particularly polyp 5), the pronounced error seen with both 2D and 3D CT colonographic measurements is best explained by an overestimation of polyp size at optical colonoscopy, which is clearly not a perfect reference standard.

Our findings indicate that restricting polyp measurement to the 2D transverse view is a suboptimal strategy because use of this projection routinely resulted in relatively significant underestimation of polyp size and was the "optimized" 2D plane in only one of 10 in vivo cases. The case of polyp 8 in our series illustrates the potential danger of using only the 2D transverse view, because all four readers measured this lesion as less than 8 mm on the transverse projection, but all 3D and 2D optimized (sagittal) measurements were higher than 10 mm. Because 10 mm represents the current size threshold for recommending polypectomy in our CT colonography screening program, this advanced adenoma may not have been properly managed if only transverse measurements had been considered. In general, polyp size can be greatly underestimated if the 2D MPR approach is not optimized.

Other pitfalls related to polyp measurement at CT colonography exist. The concept of not including the stalk when measuring pedunculated lesions is widely recognized. In some cases, the relationship of the stalk to the body of the polyp can be more fully visualized on the 3D endoluminal projection. Another potential pitfall that we have noticed relates to stool tagging, because some polyps have a tendency to retain a barium coating. Although this coating is typically quite thin, the optimized 2D measurement may be preferable to the 3D measurement in this setting because the latter measurement could potentially overestimate polyp size.

There were several limitations to our study. Although 2D MPR measurements are fairly standardized across different CT colonography systems, the same cannot be said for measurements on 3D endoluminal volume-rendered views (18). The fact that we evaluated only one CT colonography software system precludes broad generalizations about the accuracy of 3D polyp measurement with other systems. In fact, some systems may not even enable one to obtain reliable measurements on the 3D view. Clearly, for the system we evaluated, 3D polyp measurement was closer to "truth" than 2D measurement, primarily owing to size underestimation with the latter measurement. It is likely that 2D measurements would improve somewhat with the use of nonstandard oblique planes to optimize polyp diameter, but this complex task would add time to an already lengthy interpretation.

Although we did not directly address this in this study, CT window and level settings can have a strong influence on manual polyp measurement. The settings that we prefer for polyp detection are not necessarily optimized for polyp measurement; this area requires further investigation. The polyps used for measurement in this study were somewhat idealized because all were located in well-distended air-filled colonic segments and all had relatively standard morphologic features. In clinical practice, there is a wide range of polyp morphologic features, which can have complex relationships with haustral folds or points of curvature along the colonic wall. For polyps located in poorly distended segments, 2D measurement may be more feasible, whereas elongated polyps situated on complex or thickened folds may be better assessed with 3D views. Finally, use of the optical colonoscopy measurement as the in vivo reference standard is far from perfect. However, measurement with the calibrated linear probe at colonoscopy most likely represents the best reference standard available, even compared with ex vivo measurement at pathologic examination (1).

Future developments focused on more complete polyp assessment at CT colonography will likely include volume estimation (19). Because polyp volume is a much more sensitive indicator of change than polyp diameter, it could be used for noninvasive observation of unresected polyps. Polyp volume also corrects for the wide variation in polyp morphologic features that can be seen, because use of the longest single polyp dimension may overestimate clinical importance in the case of a more slender elongated polyp. Our screening program currently offers patients the option of noninvasive CT colonographic surveillance for detected lesions that measure less than 10 mm in diameter. Although validation and standardization of polyp volume assessment are still needed, the interval change in polyp volume at CT colonography follow-up will perhaps eventually become the major criterion for management of these lesions in the future.

In conclusion, we found that linear polyp measurement on the 3D endoluminal view was significantly more accurate than measurement on individual 2D MPRs, both in vitro and in vivo, for the CT colonography system we evaluated. To reduce the risk of gross underestimation of polyp size with 2D measurement, the optimized (largest) 2D MPR value should be ascertained and reported. For polyps that border a critical size threshold, we recommend careful consideration of both the 3D endoluminal and the optimized 2D MPR measurements.

Acknowledgment: We acknowledge the efforts made by Bruce Whiting, PhD (Electronic Radiology Laboratory, Mallinckrodt Institute of Radiology, Washington University School of Medicine, St Louis, Mo), in the construction and CT scanning of the colon phantom.

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