Feasibility of Tangerine Juice Sacs as Contrast Agent for MR Imaging of the Gastrointestinal Tract

Xiao-feng Mao, MS
Hong Chen
Wen-zhi Li
Zhi-yan Chang, BS

Magnetic resonance (MR) imaging of the gastrointestinal (GI) tract involves imaging the GI tract after filling it with a special contrast agent. Advantages of MR imaging are a lack of ionizing radiation, the ability to observe the GI tract and other structures (eg, liver, gallbladder, pancreas, spleen, and kidneys), and visualization of the internal and external structures of the GI wall.

Many oral contrast agents can be used for MR imaging of the GI tract, including water, polyethylene glycol, sorbitol, mannitol, fruit juices, dilute barium sulfate, and locust bean gum.[1-5] In China, isotonic mannitol commonly is used as a contrast agent in MR imaging of the GI tract.[1] However, the recommended concentration of isotonic mannitol is inconsistent in the literature, and maintaining a constant osmotic pressure for different individuals is difficult due to varying physiological and environmental factors. As a result, patients can experience abdominal distension, diarrhea, and other discomforts.[1-3] In addition, contrast agents, whether liquid or colloidal, can become diluted or concentrated in the GI tract. The primary challenge encountered with oral contrast agents is inadequate and inconsistent distension of the stomach lumen and small bowel loops.[5,6]

International studies have explored the use of fruit juices, such as acai, blueberry, or pineapple, as oral negative contrast agents.[7-10] These fruit juices contain heavy metals like manganese, which appear as short T1- and T2-weighted signals in MR imaging, creating a sharp contrast with the gastric walls. This approach has been shown to cause no serious adverse effects in patients.[8] However, the short T1-weighted signal can interfere with subsequent contrast-enhanced examinations. In addition, the studies[7-10] did not consider global availability of certain fruits, whether metal component ratios vary in fresh vs aged fruit, or whether imaging would meet diagnostic requirements if gastric juice retention dilutes the fruit juice.

Tangerines are widely cultivated, easily accessible, and inexpensive worldwide, and they are acceptable to most people with dietary restrictions. Tangerine juice sacs (ie, juice vesicles or pulp) have relatively low sugar content and are absorbed in the ileum after oral administration owing to their outer envelope. Therefore, patients with diabetes can tolerate swallowing a large amount of them at one time. Tangerine juice sacs—functioning as biphasic contrast agents and the soft-solid phase—have high water content, stable morphological features, and excellent GI lumen dilation. They reduce peristaltic artifacts, enhance image clarity, and exert no adverse stimulation on the GI tract. Therefore, tangerine juice sacs may have potential use in MR imaging of the GI as well as in studying GI motility.[6,11,12]

Materials and Methods

The authors' imaging department explored the use and feasibility of tangerine juice sacs as a contrast agent for MR imaging of the GI tract. Five volunteers were recruited, including 3 men and 2 women. The youngest participant was aged 25 years, the oldest was

Table 1
Parameters for the Magnetic Resonance (MR) Imaging Sequence

Sequence	TR, ms	TE, ms	TI, ms	NEX	FOV, cm	Slice thickness, mm	Slice gap, mm
Breath-hold coronal 2D-FIESTA	3.6	1.3	200	1	40 x 40	5	1
Respiratory-triggered axial fat-suppressed FSE	10 000	81.6	-	2	38 x 30.4	6	1.2
Breath-hold axial FSPGR echo	205	2.3	-	1	38 x 30.4	6	1.2
MRCP: 3D–fast recovery FSE	7059	596	-	-	35 x 35	2	–1

Abbreviations: FIESTA, fast imaging employing steady-state acquisition; FOV, field of view; FSE, fast spin echo; FSPGR, fast spoiled gradient-recalled; MRCP, magnetic resonance cholangiopancreatography; NEX, number of excitations; TE, echo time; TI, inversion time; and TR, repetition time.

aged 55 years, and the mean age was 41 years. The Research Ethics Committee of The Second People's Hospital of Changzhi approved the study protocol (CZEYLL2025--018).

Examination Preparation

Participants were required to fast for 4 to 6 hours before the examination. Approximately 1000 g of tangerines were peeled by removing the outer peel and the white pith. The juice sacs of the tangerines were broken into loose clusters to facilitate swallowing; separating each individual juice sac was not necessary. Approximately 250 g of tangerine juice sacs were swallowed (without chewing) 30 minutes before the examination to allow them to fill the small intestine. After the 30-minute period, 10 mg of anisodamine was injected intramuscularly in the gluteus medius to inhibit GI peristalsis. Next, approximately 500 g of tangerine juice sacs were swallowed (without chewing) to fill the stomach, after which the examination was performed.

Equipment and Scanning Protocols

The examinations were performed on an Optima MR360 1.5 T MR system (GE HealthCare). Respiratory instruction was conducted before the examination. Some scanning sequences required holding the breath at the end of expiration while others required uniform breathing. The body array coil was placed, a respiratory belt was used to monitor breathing patterns, and patients were positioned supine with their feet entering the scanner first.

The examinations were completed in 2 steps. First, upper abdominal scanning centered at the xiphoid process was performed. The coronal scanning range extended from the dome of the diaphragm to the upper part of the pelvic cavity. The acquisition sequences and parameters used in the first step are found in **Table 1**. Second, after an interval of 40 minutes, with a point 2 cm above the umbilicus as the center, the breath-hold axial fast spoiled gradient-recalled echo, breath-hold coronal 2D–fast imaging employing steady-state acquisition, and respiratory-triggered axial fat-suppressed fast spin echo sequences were repeated.

Image Evaluation

Two experienced radiologists evaluated the degree of distention of the stomach, duodenum, jejunum, and ileum; the performance of the wall of the GI tract; the uniformity and recognizability of the contrast agent signal; and the influence of local artifacts. Radiologists in this study had 10 years or more of experience, and the radiologic technologists performing the examinations had senior attending or senior professional titles. The degree of dilatation of the GI tract, the uniformity of the contrast medium, the degree of the contrast difference with the GI tract, and local artifacts were used as evaluation conditions. Based on these factors, the images were rated as:

- excellent – Lumen is well distended, contrast agent signal is uniform, GI wall is clearly displayed, and few or no artifacts are visualized.

- good – Lumen distention is not ideal, contrast agent signal can be distinguished, GI wall is moderately displayed, and a small number of artifacts are present; diagnostic image quality is not affected.
- poor – Lumen is poorly distended, contrast agent signal cannot be distinguished, GI wall is not well displayed, and there are obvious artifacts; image is not of diagnostic quality.

Results

None of the 5 participants experienced GI adverse effects during or after the examination. The GI wall was most clearly shown on the T1-weighted fat-saturated images. The lumen of the stomach and jejunum were distended adequately, and there were no peristaltic artifacts. The tangerine juice sacs presented uniform, granular low signal intensity, and the gastric wall was clearly displayed (see **Figure 1**). Four of 5 images of the gastric region were rated as excellent, and 1 image was rated as good because of the interference of local gas artifacts.

On T2-weighted fat-saturated images, the contrast agent (ie, tangerine juice sacs) was shown most clearly. The stomach and jejunum were well distended, with the juice sacs in the lumen remaining intact and undigested, presenting a uniform, granular high signal intensity. The contours and folds of the stomach and intestine were clearly visible, and there were no peristaltic artifacts (see **Figure 2**). In the ileum, differentiation was difficult due to the rupture and digestion of some of the juice sacs. The ileum lumen was poorly distended, and the bowel wall was not well displayed, resulting in a poor rating of the ileum images. Most of the duodenum images were rated as good because the peristalsis of the duodenum was too rapid for the juice sacs to fill the tract adequately.

The MR cholangiopancreatography images of all 5 participants were well visualized, with the bile ducts and pancreatic ducts clearly shown. The stomach, duodenum, and jejunum were filled with intact and undigested juice sacs. The juice sacs showed uniform, granular, and slightly high signal intensity and did not affect visualization of the biliary tract (see **Figures 3** and **4**). The high signal intensity in the antrum of the stomach, which overlapped with the common bile duct, could be eliminated through postprocessing.

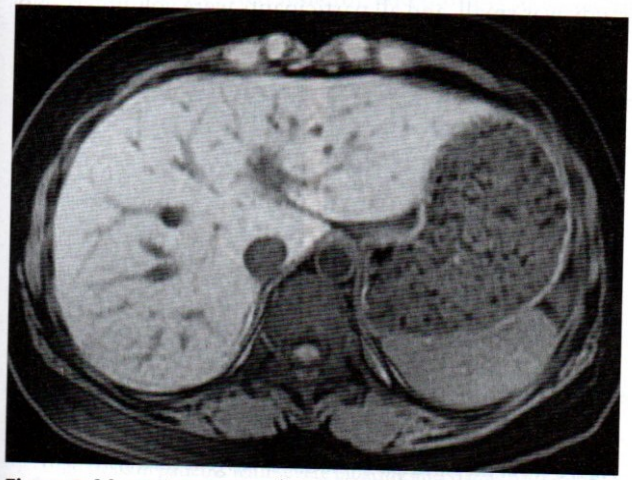


Figure 1. *Magnetic resonance (MR) imaging shows the stomach distended with juice sacs, presenting uniform, granular low signal intensity on fat-saturated T1-weighted imaging. The diminished gastric peristalsis enables clear visualization of the gastric wall. Image courtesy of the authors.*



Figure 2. *A coronal fat-saturated T2-weighted MR image shows that the juice sacs in the jejunum remain intact and undigested (arrow), presenting uniform, granular high signal intensity. Image courtesy of the authors.*

The juice sacs remained undigested in the stomach, duodenum, and jejunum, maintaining their intact morphological features. They appeared as uniform, granular structures with long T1-weighted and long T2-weighted signals. On T1-weighted images, their signal intensities were substantially lower than those of the GI wall, while on T2-wieghted images, their signal intensities were substantially higher than those of the GI wall. Shape and contour of the GI tract were clearly displayed, image noise was low, and there were no obvious motion artifacts. The images of the stomach and jejunum could meet the requirements for clinical diagnosis, and the images of the duodenum and ileum could provide useful references for clinical practice (see **Table 2**).

Discussion

The authors' department has used tangerine juice sacs as a contrast agent, which has some advantages. Tangerine juice sacs are high in water content with consistent particle sizes. They are enclosed in a membranous layer and not digested in the stomach, duodenum, or jejunum. Tangerine juice sacs are an oral biphasic contrast medium, demonstrating long uniform granular T1- and T2-weighted signal intensities, which are markedly different from the equal T1- and T2-weighty signal intensities of the GI wall. As soft-solid structures, tangerine juice sacs fill the GI tract, substantially reducing peristalsis to minimize motion artifacts on MR imaging and enhance image quality. Because the juice sacs are plant based, they exert minimal effect on the biliary system and do not interfere with MR cholangiopancreatography performance.[6,8]

Before using tangerine juice sacs as contrast agents, 3 notable factors should be considered. Firstly, tangerine juice sacs need to be swallowed without chewing; therefore, patients with esophageal diseases and those who have difficulty swallowing are not suitable for this examination. In addition, those with contraindications for MR imaging cannot undergo this examination. Furthermore, tangerine juice sacs are ruptured and digested in the ileum, resulting in insufficient distention of the tract and poor visualization of the ileum wall.

Limitations

Because MR imaging has a low spatial resolution, mild gastritis, small polyps, and small ulcers might have been missed during diagnosis. The sample size for this study was small, and all participants were volunteers. No

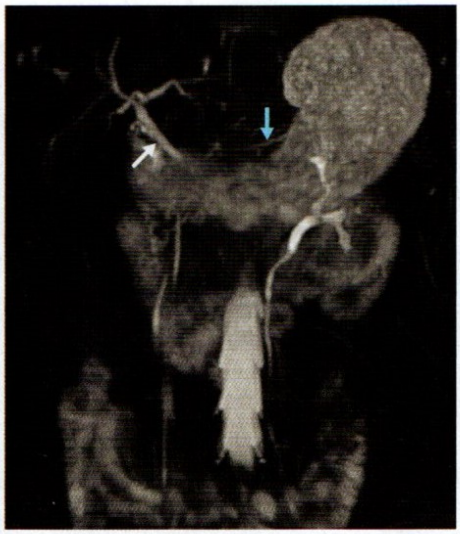


Figure 3. *Magnetic resonance cholangiopancreatography (MRCP) imaging of a participant who had previously undergone cholecystectomy exhibits clear visualization of the common bile duct (white arrow) and pancreatic duct (blue arrow). The high signal intensity in the antrum of the stomach, which overlapped with the common bile duct, could be eliminated through postprocessing. The stomach, duodenum, and jejunum were filled with juice sacs. These sacs retained their morphological features, remained undigested, and presented uniform, granular high signal intensity. Image courtesy of the authors.*

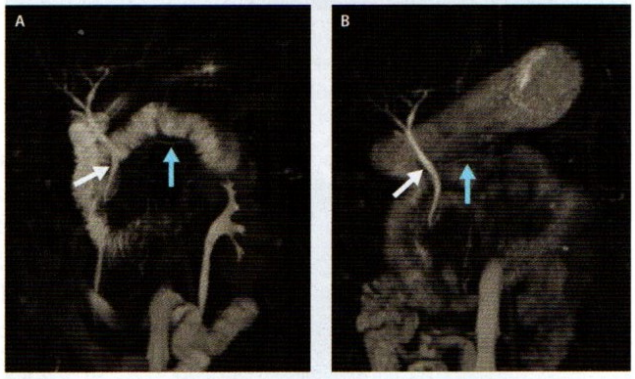


Figure 4. *For the participant who had undergone cholecystectomy previously (shown in Figure 3), the fasting MRCP image (A) and the MRCP images generated after the participant swallowed the juice sacs (B) clearly display the common bile duct (white arrows) and pancreatic duct (blue arrows). Moreover, there is no substantial alteration in the diameter of these ducts. Images courtesy of the authors.*

Table 2

Ratings for Gastrointestinal MR Images Per Participant

Participant	Stomach	Duodenum	Jejunum	Ileum	MRCP
1	Excellent	Good	Excellent	Poor	Excellent
2	Excellent	Good	Good	Good	Excellent
3	Excellent	Good	Excellent	Good	Excellent
4	Good	Poor	Excellent	Poor	Excellent
5	Excellent	Good	Excellent	Poor	Excellent

controls were used with other oral GI contrast agents, which can affect the generalizability of the research results and the objectivity of comparative analysis.

Conclusion

A range of oral contrast agents is available for MR imaging of the GI tract, including water, polyethylene glycol, sorbitol, mannitol, fruit juices, dilute barium sulfate, and locust bean gum. However, these agents often fail to achieve consistent gastric and small bowel distension. Tangerine juice sacs, functioning as biphasic agents with high water content and stable morphology, provide superior luminal expansion, minimize peristaltic artifacts, and enhance image quality without inducing adverse GI effects. These properties suggest potential utility in MR imaging and motility assessment of the GI tract.

Xiao-feng Mao, MS; Hong Chen; Wen-zhi Li; and Zhi-yan Chang, BS, work for The Second People's Hospital of Changzhi in Shanxi Province, China.

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