Wireless Motility Capsule: the SMARTest pill around

A New Technology to Measure Intestinal Transit

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Motility Journal Club
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Overview

• Background of GI Motility Disorders: Gastroparesis and Slow Transit Constipation
• WMC: Technology review
• Literature review
• Summary & Conclusion
Overview

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GI Motility Disorders

Gastroparesis (GP)

- Delayed gastric emptying in the absence of mechanical obstruction
- Diabetic, idiopathic, post-surgical, and other etiologies
- Age-adjusted prevalence: 9.6 and 37.8 per 100,000 person-yrs for men & women


Gastroparesis

- Most common symptoms: nausea, abdominal pain, early satiety, and vomiting
- Exam: epigastric distension, tenderness, succussion splash
- Most often diagnosed via scintigraphic gastric emptying study (GES)

Gastric emptying scintigraphy

Suggested method:
• oral consumption of a radiolabeled egg meal (Tc99m-labeled sulfur colloid)
• multiple sequential anterior and posterior images of the abdomen are obtained usually at 0, 1, 2, and 4hr
• A time/activity curve is generated using region-of-interest analysis at each time point
• The report should contain the normal values at the key time points: 1 h (37–90%), 2 h (30–60%), and 4 h (0–10%)

Gastric emptying scintigraphy

Advantages
• Widely available
• Low cost
• Simple to perform

Disadvantages
• Radiation exposure
• Requires at least 2-4 hrs (depending on how performed)
• Often not standardized technique
Gastric emptying scintigraphy

- **Tougas *et al.* 2000:** multicenter, international study which provided much-needed normative data using a simplified GES
- **Recommended measuring the % residual of the meal remaining at 4 h to differentiate delayed from normal emptying**
- **Gastric retention of >10% of the meal at 4 h is considered diagnostic of a significantly delayed gastric emptying**

Slow Transit Constipation

- Background of GI Motility Disorders: Gastroparesis and Slow Transit Constipation
- WMC: Technology review
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Slow Transit Constipation

• Defined by abnormal colonic transit/ delayed passage of radiopaque markers (ROM) through the proximal colon

• Severe idiopathic chronic constipation
  • Normal transit constipation (NTC)
  • Slow transit constipation (STC)
  • Outlet delay
Slow Transit Constipation

- Average number of physician visits for constipation in the US is 2.5 million per year, prevalence of ~1.2%
- Most widely used test for diagnosis is the colonic transit study/ ROM study


Colonic Transit Study

- Typically, ingestion of a single Sitzmarks capsule containing 24 ROM on Day 1
- Plain AXR on Day 6
- Normal transit: less than 5 markers remaining
- Slow transit: 5 or more
Colonic Transit Study

Advantages
• Cheap
• Widely available

Disadvantages
• Radiation
• Lack of standardization
• Sometimes need multiple visits
Colonic Transit Study

- No single test for constipation adequately defines pathophysiology
- No comparison gold standard in studies evaluating colonic transit study
- Systematic review 2005 (10 studies): proportion of pts with constipation with abnormal test: 38 to 80% i.e. slow transit constipation
- Also, test is reproducible in patients with normal transit constipation

WMC: Technology review

• Background of GI Motility Disorders: Gastroparesis and Slow Transit Constipation

• WMC: Technology review

• Literature review

• Summary & Conclusion
WMC – the basics

- FDA approved ingestible capsule
- Utilizes a sensor to record pH, pressure and temperature from entire GI tract
- Evaluates GI motility, specifically *gastroparesis* and *constipation*
- Wirelessly transmits data to a data receiver for analysis
How does it work?

1. Patient fasts overnight

2. Patient ingests standardized meal bar (replaces egg meal of GES), swallows the capsule in physician’s office and then wears data receiver

3. Patient can be ambulatory; data receiver records and stores data from capsule

4. Patient returns data receiver to physician’s office

5. Data are downloaded to a computer

6. Special software to graphically display test data

7. Review collected data -> interpretation and report
WMC

Can determine:

1. Gastric emptying time
2. Small bowel transit time
3. Colonic transit time
4. Whole gut transit time
5. Amplitude of distal antral and duodenojejunal contractions
6. Amplitude of phasic contractions of the colon
7. Intragastric acidity
### Test Summary

#### Patient Information

<table>
<thead>
<tr>
<th>Patient Name</th>
<th>ID</th>
<th>Test Start Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1308525</td>
<td>5/15/2009</td>
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</tbody>
</table>

#### Transit Times

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Physician-Confirmed (hr:min)</th>
<th>Computed (hr:min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastric Emptying Time</td>
<td>17:42</td>
<td>17:41</td>
</tr>
<tr>
<td>Small Bowel Transit Time</td>
<td>6:48</td>
<td>6:47</td>
</tr>
<tr>
<td>Colonic Transit Time</td>
<td>68:32</td>
<td>68:35</td>
</tr>
<tr>
<td>Small/Large Bowel Transit Time</td>
<td>75:21</td>
<td>75:23</td>
</tr>
<tr>
<td>Whole Gut Transit Time</td>
<td>93:03</td>
<td>93:04</td>
</tr>
</tbody>
</table>

*Courtesy of Dan Holmberg, SmartPill Corp.*
Literature Review

• Background of GI Motility Disorders: Gastroparesis and Slow Transit Constipation
• WMC: Technology review
• Literature review
• Summary & Conclusion
Hypothesis: strong, + correlation in gastric emptying measures between gastric emptying time (GET) and gastric emptying scintigraphy (GES) and comparable ability to distinguish between healthy vs gastroparetics

- Prospective study
- Multicenter
- 2005
Study Subjects

- Exclusion criteria: GI surgery, drugs that would effect motility
- 87 Healthy subjects (H) (52M, 32F) enrolled age 18-65
- 61 Gastroparetics (GP) (10M, 51F) enrolled age 18-65 (6 mo of Sx + abnormal GES within 2 yrs)

= total 148 subjects
Methods

- Capsule GET: from ingestion to abrupt rise pH (>3) from gastric baseline (i.e. entering duodenum) – assessed by 2 independent reviewers
- GES: standardized $^{99m}$Tc labelled egg meal; capsule ingested 1st with water, then egg meal
- Scintigraphic images taken after meal, q30min to 4hr; 6hr image if <90% emptying at 4hr
- At 6 hrs, 250ml Ensure ingested
Methods

• 8hr: left w/ data receiver
• Symptoms, BM, food diary kept
• No alcohol, exercise, ab crunches, motility meds
• 48-72hr: returned diary and receiver; if didn’t return capsule, AXR taken
Results

• **1º objective**: correlations btwn GET and GES 2hr & 4hr end points

• **2º objective**: determine diagnostic utility of the 2 tests in distinguishing H vs GP: sensitivity, specificity, ROC curve w/ AUC
Study Subjects

• **148** subjects enrolled → **125** used for analysis
  -> 2 did not participate
    -> 16 missing GET data b/c equipment malfunction
    -> 5 excluded b/c GET capsule <30min
Healthy vs. Gastroparesis

Comparison of meal remaining and pH levels over time.
In each group plot, the times of healthy subjects were all statistically significantly different from GP with p<0.05

<table>
<thead>
<tr>
<th>Gastric emptying measure</th>
<th>Healthy subjects</th>
<th>Gastroparetic subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>GET (min)</td>
<td>215 (199–225), n = 77</td>
<td>&gt;360 (320, &gt;360), n = 48</td>
</tr>
<tr>
<td>GES-2 h (% of meal retained)</td>
<td>25% (23–37%), n = 87</td>
<td>51% (42–58%), n = 59</td>
</tr>
<tr>
<td>GES-4 h (% of meal retained)</td>
<td>1% (1–1.4%), n = 87</td>
<td>9% (4–13%), n = 59</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gastric emptying parameter</th>
<th>SP-GET correlation (95% CI)</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>AUC (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GES-2 h</td>
<td>0.63 (0.50–0.75)</td>
<td>0.34</td>
<td>0.93</td>
<td>0.79 (0.71–0.88)</td>
</tr>
<tr>
<td>GES-4 h</td>
<td>0.73 (0.61–0.82)</td>
<td>0.44</td>
<td>0.93</td>
<td>0.82 (0.77–0.91)</td>
</tr>
<tr>
<td>GET</td>
<td>n/a*</td>
<td>0.65</td>
<td>0.87</td>
<td>0.83 (0.74–0.90)</td>
</tr>
</tbody>
</table>

* Not applicable.
Results

• Additional analysis: 72/77 H had N GES 4hr and 23/48 GP had abN GES 4hr
• Reclassified based on above...
  ➔ AUC for GET 0.94, Sensitivity 0.87, and Specificity was 0.92
• Therefore, cut-off pt for GET optimal for clinical use established as 300min
<table>
<thead>
<tr>
<th>Body system</th>
<th>Reported term</th>
<th>Not related (n)</th>
<th>Probably not related (n)</th>
<th>Definitely related (n)</th>
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<tbody>
<tr>
<td>Cardiovascular</td>
<td>Dizziness upon standing</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Gastrointestinal</td>
<td>Bloating</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Capsule retention</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Nausea</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Vomiting</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Stomach pain</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Abdominal pain</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nervous</td>
<td>Taste bitter</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nonspecific skin</td>
<td>Burn local</td>
<td>0</td>
<td>1</td>
<td>0</td>
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<tr>
<td>Total number of AE subjects</td>
<td></td>
<td>6</td>
<td>3</td>
<td>1</td>
</tr>
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</table>
Conclusion

Large, prospective study showing clinically significant correlation between WMC GET and GES 4hr for evaluation of gastric motility in healthy pts and gastroparetics. The sensitivity and specificity of WMC is comparable to GES.
Limitations

- Only 23/48 GP had abN GES - index scintigraphy: performed at OSH, thus different technique
- Gender mismatch on H vs GP
- 16/146 technical WMC failures
- Sponsored by Smartpill Corp.
Hypothesis: WMC can assess CTT and WGTT, distinguish btwn NTC and STC, and provide comparable information as ROM

- Multicenter
- Prospective
Methods

• Chronic constipation subjects: per Rome II criteria & reported 2/6 Sx of constipation
• D/c all meds that influence motility 48 hrs before & PPIs
• Healthy subjects recruited via Mayo GI Disease questionnaire
Methods

1. Overnight fast
2. Ingest 260 kcal Smartbar with water
3. ROM capsule swallowed
4. WMC swallowed, receiver worn
5. Observation x 6 hrs
6. At 6 hrs, Ensure
7. Stool, Sx, Food diary x 5 days
8. AXR 48hrs after WMC ingestion
9. AXR at 5 days to check # ROM
Definitions

GET: Ingestion of WMC to abrupt pH increase from gastric baseline

SBTT: Entry into SB to entry into cecum (drop in pH by 1 unit for >10min, 30min or more after entry into SB)

CTT: Entry into cecum to exit from body (temp drop/ loss of signal)

WGTT: Ingestion of WMC to exit
CONSTIPATED
Results

• 1\textsuperscript{st} objective: relationship between CTT and WGTT w/ # retained ROM on day 2 and 5

• Diagnostic utility of WMC to identify STC -> ROC curve where AUC = diagnostic accuracy
Demographics

- 165 enrolled
- 78 constipated (69 F, 9 M)
- 87 Healthy (40F, 47M)
- 12 subjects: software malfunction
- Cecal arrival time not recognizable in 5 ->148 capsule data
- Problems with AXR -> 153 ROM data
Table 1. Median (25th–75th Percentiles) Values for CTT, WGTT, GET, and SBTT as Measured by the SmartPill in Constipated Subjects and Healthy Controls, and the Effects of Sex

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>Women only</th>
<th>Men only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Constipated (n = 67)</td>
<td>Healthy (n = 81)</td>
<td>P value</td>
</tr>
<tr>
<td>CTT, h</td>
<td>46.7 (24.0–91.9)</td>
<td>21.7 (15.5–37.3)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>WGTT, h</td>
<td>59.3 (39.7–97.9)</td>
<td>29.7 (22.4–45.7)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>GET, h</td>
<td>3.5 (3.0–4.2)</td>
<td>3.0 (2.5–3.9)</td>
<td>.0123</td>
</tr>
<tr>
<td>SBTT, h</td>
<td>4.2 (3.5–5.1)</td>
<td>3.8 (3.2–4.7)</td>
<td>.0908</td>
</tr>
</tbody>
</table>

|                  | Constipated (n = 59) | Healthy (n = 39) | P value          |
| CTT, h           | 46.7 (24.0–91.9)    | 24.7 (17.3–43.2) | .0013            |
| WGTT, h          | 58.0 (39.7–97.9)    | 33.9 (25.7–51.0) | .0004            |
| GET, h           | 3.4 (3.0–4.1)       | 3.5 (2.7–4.2)    | .8414            |
| SBTT, h          | 4.2 (3.5–5.2)       | 3.8 (2.9–4.9)    | .2530            |

|                  | Constipated (n = 8) | Healthy (n = 42) | P value          |
| CTT, h           | 50.9 (25.2– )      | 18.7 (13.3–26.8) | .0264            |
| WGTT, h          | 72.2 (36.3– )      | 25.6 (20.8–33.9) | .0115            |
| GET, h           | 4.2 (3.6– )        | 2.7 (2.4–3.7)    | .0054            |
| SBTT, h          | 4.4 (3.4–4.8)      | 3.8 (3.3–4.5)    | .4667            |

*Seventy-fifth percentile not observed for CTT, WGTT, and GET because of capping of data.

CTT slower in constipated men and women vs controls P <0.0001

Figure 2. Box-and-whisker plots for SmartPill CTT in healthy and constipated subjects, and effects of sex. CTT was significantly slower in constipated women and men compared with controls.
Figure 3. Box-and-whisker plots for (A) GET, (B) SBTT, and (C) WGTT. GET and WGTT were slower in constipated subjects.
### Table 3. Correlation of CTT and WGTT as Measured by the SmartPill With the Number of Retained ROMs

<table>
<thead>
<tr>
<th>SmartPill parameter</th>
<th>Overall group day 2 ROM (95% CI)</th>
<th>Day 2 ROMs in healthy subjects</th>
<th>Day 2 ROMs in constipated subjects</th>
<th>Overall group day 5 ROM (95% CI)</th>
<th>Day 5 ROMs in healthy subjects</th>
<th>Day 5 ROMs in constipated subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTT</td>
<td>0.78 (0.70–0.84)</td>
<td>0.70</td>
<td>0.74</td>
<td>0.59 (0.46–0.69)</td>
<td>0.40</td>
<td>0.69</td>
</tr>
<tr>
<td>WGTT</td>
<td>0.77 (0.68–0.84)</td>
<td>0.74</td>
<td>0.67</td>
<td>0.58 (0.45–0.69)</td>
<td>0.39</td>
<td>0.66</td>
</tr>
</tbody>
</table>

CI, confidence interval.

### Table 4. AUC of the ROC Curve, Sensitivity and Specificity for the SmartPill CTT and WGTT, and Day 5 ROMs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>AUC (95% CI)</th>
<th>Cut-off value</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTT</td>
<td>0.73 (0.65–0.82)</td>
<td>59 h</td>
<td>0.46</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>All subjects</td>
<td>Men</td>
<td>44 h</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Women</td>
<td>59 h</td>
<td>0.46</td>
</tr>
<tr>
<td>WGTT</td>
<td>0.76 (0.68–0.84)</td>
<td>All subjects</td>
<td>73 h</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>All subjects</td>
<td>Men</td>
<td>52 h</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Women</td>
<td>73 h</td>
<td>0.41</td>
</tr>
<tr>
<td>Day 5 ROM</td>
<td>0.71 (0.63–0.78)</td>
<td>All subjects</td>
<td>&gt;5 markers</td>
<td>0.37</td>
</tr>
</tbody>
</table>

CI, confidence interval.
Conclusion

• Large, prospective study demonstrates that WMC can be used to measure regional and whole gut transit and WMC correlates well with ROM in healthy subjects compared to pts with constipation.
Limitations

- Gender imbalance between controls and constipated
- Young population <65 yrs
- 12/165 had technical problems with capsule
- Funded by Smartpill Corp
Hypothesis: WMC equivalent to ROM in assessment of CTT and combined colonic and SBTT in constipated patients

- Prospective
- Multicenter
Participants

- Chronic constipation: by Rome III criteria emphasizing abnormal stool consistency
- Eligibility criteria: both sexes, age 18-80 w/ Sx x 1 yr, hard stool 25% time, 1/6 Sx of functional constipation
- PPI held x 7 days, H2 blockers x 3 days, and antacids x 1 day
Study Design

1. WMC and ROM ingestion Day 1
2. ROM on Day 2 and Day 3 independently
3. Day 4 AXR
4. Day 7 AXR – if necessary
5. Daily diary to record stool consistency
Results

1º endpoints: positive and negative agreements between WMC CTT and ROM colonic transit as well as WMC SLBTT and ROM colonic transit

- SLBTT used as a surrogate measure of colonic transit when CTT not available
- Generally SLBTT closely approximates CTT
- Exact binomial tests for positive and negative agreement, each at significance 0.0253
• 47 of 59 pts with delayed colonic transit by ROM had delayed CTT by WMC
• positive percent agreement = 80% (0.67-0.98), p = 0.01
• negative % agreement is 89/98 = 90% (0.83-0.96) p = 0.00001
• Overall device agreement 86%

Table 1 Number of patients with agreement [a] between CTT by WMC and Day 4 + Day 7 ROM colonic transit [+ or −, delayed; −, normal transit] and [b] between small and large bowel TT by WMC and Day 4 + Day 7 ROM colonic transit [+ or −, delayed; −, normal transit]

<table>
<thead>
<tr>
<th></th>
<th>D4 + D7 ROM+</th>
<th>D4 + D7 ROM−</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>[a]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WMC CTT+</td>
<td>47</td>
<td>9</td>
<td>56</td>
</tr>
<tr>
<td>WMC CTT−</td>
<td>12</td>
<td>89</td>
<td>101</td>
</tr>
<tr>
<td>Total</td>
<td>59</td>
<td>98</td>
<td>157</td>
</tr>
<tr>
<td>[b]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WMC SLBTT+</td>
<td>46</td>
<td>9</td>
<td>55</td>
</tr>
<tr>
<td>WMC SLBTT−</td>
<td>12</td>
<td>87</td>
<td>99</td>
</tr>
<tr>
<td>Total</td>
<td>58</td>
<td>96</td>
<td>154</td>
</tr>
</tbody>
</table>

CTT, colonic transit time; WMC, wireless motility capsule; ROM, radiopaque marker.
Table 2  Median [25th, 75th percentile] gastric emptying and small bowel transit times in minutes, as determined by the WMC, in patients classified by both ROM and WMC

<table>
<thead>
<tr>
<th>Overall group</th>
<th>Gastric emptying time</th>
<th>Small bowel transit time</th>
<th>Orocecal transit time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NTC</td>
<td>STC</td>
<td>NTC</td>
</tr>
</tbody>
</table>

NTC, normal transit constipation; STC, slow transit constipation; ROM, radiopaque marker; WMC, wireless motility capsule.
WMC CTT = 10.653 + (0.670 * ROM (D4+7)),
$R = -0.707, P < 0.001$

WMC SLBTT = 14.684 + (0.672 * ROM (D4+7)),
$R = 0.704, P < 0.001$
<table>
<thead>
<tr>
<th>System organ class</th>
<th>AE relationship to the study device (N)</th>
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</thead>
<tbody>
<tr>
<td>Gastrointestinal disorders</td>
<td>Not related</td>
</tr>
<tr>
<td>Preferred term</td>
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<tr>
<td>Abdominal pain</td>
<td>0</td>
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<tr>
<td>Diarrhea</td>
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<td>Dysphagia</td>
<td>0</td>
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<td>Frequent bowel movements</td>
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<tr>
<td>Gastrointestinal pain</td>
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<tr>
<td>Nausea</td>
<td>1</td>
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<tr>
<td>Vomiting</td>
<td>1</td>
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<tr>
<td>General disorders and</td>
<td>Pyrexia</td>
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<tr>
<td>administrative site conditions</td>
<td>Sluggishness</td>
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<td>Infections and infestations</td>
<td>Bronchitis</td>
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<td></td>
<td>Cystitis</td>
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<td></td>
<td>Ear infection</td>
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<td></td>
<td>Pharyngitis streptococcal</td>
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<td>Tooth abscess</td>
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<td></td>
<td>Upper respiratory tract infection</td>
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<td>Postprocedural complication</td>
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<tr>
<td>Injury, poisoning and procedural</td>
<td>Muscle spasms</td>
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<tr>
<td>complications</td>
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<td>Musculoskeletal and connective</td>
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<td>tissue disorders</td>
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<td>Nervous system disorders</td>
<td>Headache</td>
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<td></td>
<td>Migraine</td>
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<tr>
<td>Respiratory, thoracic and</td>
<td>Asthma</td>
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<tr>
<td>mediastinal disorders</td>
<td></td>
</tr>
<tr>
<td>Total number of adverse events</td>
<td>14</td>
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</table>
Conclusion

Prospective, large, multicenter study in patients with constipation showed 87% overall agreement, both positive and negative, between WMC and ROM in distinguishing between STC and NTC.
Limitations

• Fewer restrictions than other studies re food, fiber, exercise during study period
• Metcalf method not used in other studies evaluating same issue
• Gender discrepancy
• Lack of control group
• Funded by Smartpill Corp
Additional Studies

- **Maqbool 2009**: WMC assessment of gastric emptying and WGTT was equivalent to whole gut scintigraphy in 10 healthy subjects.
  - $R = 0.95$ between GES 2hr and WMC GET; $0.70$ for GES 4hr and WMC GET.

- **Sarosiek 2010**: WMC assessment of GET, SBTT, CTT, and WGTT in healthy and GP pts.
  - GET, CTT, and WGTT was longer in GP pts vs controls.

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Summary & Conclusion

• Background of GI Motility Disorders: Gastroparesis and Slow Transit Constipation

• WMC: Technology review

• Literature review

• Summary & Conclusion
If the tests are basically equivalent...

<table>
<thead>
<tr>
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<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
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</table>
| **GASTRIC EMPTYING** | • EASILY AVAILABLE
|                      | • SIMPLE                            | • RADIATION
|                      | • RELATIVELY CHEAP                  | • NON STANDARDIZED TECHNIQUE practiced
|                      |                                    | • TIME CONSUMING                                   |
| **SCINTIGRAPHY**     |                                    |                                                   |
| **RADIOPAQUE MARKERS**| • WIDELY AVAILABLE
|                      | • SIMPLE                            | • RADIATION
|                      | • VERY CHEAP                        | • NON STANDARDIZED                                 |
|                      |                                    | • +/- MULTIPLE VISITS                              |
| **WIRELESS MOTILITY** | • AMBULATORY
|                      | • SIMPLE                            | • EXPENSIVE
| **CAPSULE**          | • STANDARDIZED                       | • CAPSULE RETENTION                                |
|                      | • REGIONAL TRANSIT TIMES            | • STILL TECHNICAL PROBLEMS                         |
References


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