Efficacy of spinal magnetic stimulation in elderly persons with chronic constipation

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Abstract

Background: The development of primary constipation in elderly adults usually has a multifactorial etiology. Slow transit constipation and pelvic floor dysfunction (PFD) are the two most commonly seen constipation subtypes in the elderly. PFD is usually a persistent condition that remains unresponsive to treatment in spite of various therapies currently available to relieve constipation. The aim of this study was to assess the usefulness of spinal magnetic stimulation (SMS) in controlling intractable constipation in elderly patients.

Methods: Nineteen patients over the age of 65 with intractable constipation were enrolled in this study, and participated in a 12-session magnetic conditioning protocol consisting of a 20-minute stimulation session once daily. Colonic transit time (CTT) and the dynamics of evaluation as revealed in defecography were measured, and the Knowles–Eccersley–Scott Symptom (KESS) Questionnaire was administered before the intervention, and after finishing the protocol.

Results: There was a statistically significant improvement in CTT and defecography following the intervention. The difference in the anorectal angles between resting and evacuation (p = 0.001) and the changes in pelvic floor descent (p = 0.011) both reached significance after the intervention. The mean CTT (p = 0.001), Knowles–Eccersley–Scott Symptom score (p = 0.001), frequency of bowel movement (p = 0.005), unsuccessful evacuation (p = 0.018), and time needed for bowel hygiene (p = 0.032) all showed marked improvement after SMS conditioning.

Conclusion: Our findings reveal that SMS intervention may benefit elderly patients with severe constipation. The amelioration of geriatric bowel dysfunction across the subtypes of slow transit constipation and PFD indicated that SMS, featuring broad-spectrum applications, can be an effective form of adjuvant treatment in the care of elderly adults.

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Keywords: aging; constipation; geriatric bowel dysfunction; pelvic floor dysfunction; spinal magnetic stimulation

1. Introduction

During the aging process, several factors predispose the elderly to lower gastrointestinal disorders, including structural changes, and colorectal and defecation dysfunction. The incidence of constipation increases with aging, affecting approximately 26% of men and 34% of women beyond the age of 65.1 This disease affects community-dwelling elderly and nursing home residents with a prevalence of 50–74%. It is generally assumed that functional gastrointestinal disorders do not have major adverse effects on long-term health.2 However, a recent population-based cohort study revealed that chronic constipation in the elderly is associated with a higher risk of organic diseases and poorer survival rates, in comparison with other gastrointestinal disorders, such as chronic diarrhea, abdominal pain, and irritable bowel syndrome.3 Therefore, caution should be taken when constipation develops in the elderly, and more extensive and effective treatment should be provided.
The development of constipation in elderly adults usually has a multifactorial etiology. In addition to the secondary constipation that accompanies other gastrointestinal, neurological, endocrine, and metabolic disorders, iatrogenic constipation may be associated with the consumption of several medications. Primary constipation can be categorized into three types: normal transit constipation, slow transit constipation (STC), and pelvic floor dysfunction (PFD), or as a combination of two abnormalities. Most elderly persons with associated constipation are required to modify their diets and take laxatives, stool softeners, and bulk-forming agents to produce bowel elimination. In Eastern countries, traditional Chinese medication is another option in addition to Western medicine for treating constipation. When the condition is more extreme, patients may use enemas or manual rectal stimulation. Nevertheless, pelvic floor dyssynergia is usually a persistent condition that remains unresponsive to treatment, in spite of the various therapies currently available to relieve constipation.

Recent advances in neurological and surgical interventions have offered patients alternative bowel care programs. Electrical stimulation to the sacral roots has had some success in bowel elimination, but it also has considerable disadvantages. Many patients will need further surgery or reprogramming due to technical failure or local discomfort.

On the other hand, spinal magnetic stimulation (SMS) is capable of directing extracorporeal magnetic stimulation to the spinal nerves and deep muscles to facilitate bowel elimination without surgical disadvantages. This technique has been developed to aid micturition, expiration, and bowel function in a noninvasive manner. In our previous studies, we demonstrated that by applying a magnetic coil to the T9 and L3 spinal process, the mean colonic transit time (CTT) for all spinal cord-injured patients decreased significantly, and the effect could be carried over up to 2 months after treatment. However, it is still not known whether this repeated magnetic pulsation produces a summation effect in elderly persons with constipation. Apart from evidence suggesting that SMS can induce physiological changes in neurological bowel dysfunction, its influence on geriatric constipation has not yet been established.

We formulated the protocol for this study, in an attempt to enhance bowel movements and harmonize pelvic floor contractions in the elderly. The purpose of this study was: (1) to investigate the effect of SMS on total CTT in intractable constipation and (2) to compare the changes in dynamic pelvic muscle behavior during defecation in responses to a series of SMS sessions.

2. Methods

2.1. Participants

This was a prospective, intrinsically controlled study investigating baseline and post-SMS therapeutic responses. Patients over the age of 65 and with intractable constipation were recruited prospectively for the study. We used the modified Rome III criteria for the definition of functional constipation, which was characterized by persistently difficult, infrequent, or incomplete defecation, and did not fulfill the criteria for irritable bowel syndrome. None of the patients was satisfied with their existing bowel routine. Most of the patients used laxatives or enema to complete this daily routine. Laxatives include senna compounds, lactulose, bisacodyl, and polyethylene glycol preparations. During this time, 29 patients were eligible for inclusion.

Full physical and medical history examinations were carried out to determine the neurological and medical condition of our patients. Patients with diseases or conditions that are capable of complicating bowel problems, such as Parkinson's disease, stroke, or traumatic brain injury, or patients with a history of peripheral neuropathy such as diabetics or metabolic neuropathy patients, were excluded from the study. To ensure that they did not suffer from structural abnormalities, any patients suffering from anal hemorrhoids or bleeding, or who revealed the presence of occult blood following fecal occult blood testing, underwent a total colonoscopic examination. Nineteen of the original 43 patients were eventually included in this study. Study methods were approved, and informed consent was obtained according to local institutional review board protocols for human participants and in compliance with Occupational Health and Safety Administration regulations. The group was comprised of 11 men and nine women, mean age 75.4 years (65–89 years), with a mean duration of illness of 7.4 years.

2.2. Stimulation protocol

We used the MagStim Rapid Magnetic Stimulator (Magstim Co., Whitland, Dyfed, UK) to conduct a stimulation protocol for this study. This stimulator can generate a maximum field strength of 2.2 Tesla at the center of the coil. The instrument setting and study paradigm have been described elsewhere. In brief, each participant was placed in a sitting position, and each session began with the center of the coil being placed at the T9 spinal process with 10 minutes of thoracic nerve stimulation; the coil was then placed at the L3 spinal process for another 10 minutes of lumbosacral nerve stimulation. We set the stimulation intensities at 50% of maximal output (2.2 Tesla), and for the remainder of the study we stabilized the intensity at 70%. The stimulation frequency, burst length, and inter-burst intervals were fixed respectively at 20 Hz, 2 seconds, and 28 seconds. Each participant underwent a 12-session protocol of 20-minute stimulations once daily during the 3-week period.

2.3. Evaluation methods

2.3.1. Colonic transit time

CTT was measured using a simplified version of the CTT assessment protocol because it involves less radiation exposure. CTT utilizes three distinct marker types (Sitzmark radiopaque capsule; Konsyl Pharmaceuticals, Inc., Easton,
MD, USA) that the patient ingests one by one on 3 consecutive days, followed by a single abdominal radiograph to visually record the numbers of each kind of marker. CTT assessment for each patient was carried out before receiving SMS treatment, and on the day following treatment. One capsule contained 24 radiopaque markers, each of which had a different shape, separately distinguishable on abdominal films. During CTT testing, all patients followed a normal hospital diet, but each had to suspend laxative medication, enema usage, or digital maneuvering for 3 days to avoid any disturbance of colonic motility. Localization of markers on abdominal films relied on the identification of bony landmarks and gaseous outlines. Retention of all 72 markers on Day 4 following treatment yielded an estimated transit of 72 h, a value of the upper limit using this method.

2.3.2. Defecography

We used the procedure of laying the patient on the fluoroscopic table (GE, Prestige II, Milwaukee, WI, USA) in the left lateral position. Five hundred grams (250 ml) of thick barium paste was then injected into the patient’s rectum. The paste has a similar consistency to normal stool, and produces a sensation of rectal fullness. The table was then positioned upright, and the patient was seated on a radiolucent commode. While the patient was thus at rest, lateral radiographs were taken of the voluntary contractions of the anal sphincter and of the pelvic floor muscles when they were straining downward. The anorectal angle (ARA) and perineal descent were recorded using a computer video image analysis program. Failure of the puborectalis muscle to relax and allow the ARA to open sufficiently by more than 15° indicated that the patient had puborectalis syndrome. Perineal descent was measured as the difference (in centimeters) between the anorectal junction and the line between the inferior borders of the symphysis pubis to the last coccygeal joint at rest and during straining. Poor perineal descent was defined as a difference of less than 20 mm between the two positions. A nonrelaxing puborectalis muscle and poor perineal descent are basically both major laboratory findings of PFD. The residual barium paste in the rectum was rated on a scale of 1 to 3: where 1 indicated that the patient had normal bowel habits with no sign of constipation, while a maximum score of 44 represented the worst constipation. A researcher who was unaware of the patients’ previous history, grouping status, or investigative results used each KESS questionnaire as an interview instrument with no questions omitted. The interviewer was instructed to avoid discussion with their interviewees, and to elicit the most appropriate single answer to each question during the interview.

2.4. Data analysis

We used the Wilcoxon signed-rank test to analyze the information recorded from the CTT test, KESS scores, and the changes in dynamic rectoanal behavior, and obtained an estimate of the patients’ comparative baseline and post-SMS values. Statistical tests were declared statistically significant if $p < 0.05$.

3. Results

The etiologies for constipation were categorized as SCT (53%), PFD (84%), or a combination of two abnormalities (61%), in accordance with the CTT and defecography results. There was a statistically significant improvement in CTT ($p = 0.001$), KESS score ($p = 0.001$), and the pelvic dynamic study following the SMS intervention. The values are given in Table 1. The differences in ARA between resting ($p = 0.043$) and evacuation ($p = 0.003$) were highly significant.

Table 1. Data summary of defecography, colonic transit time (hours) and score of KESS questionnaire at baseline and post-spinal magnetic conditioning.

<table>
<thead>
<tr>
<th></th>
<th>Rest (ARA, degree)</th>
<th>Evacuation (ARA, degree)</th>
<th>Difference$^a$ (degree)</th>
<th>Pelvic floor descent (cm)</th>
<th>Residual barium amount (score)</th>
<th>Colon Transit Time</th>
<th>KESS score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline (mean ± SD)</td>
<td>94.6 ± 10.9</td>
<td>97.9 ± 10.8</td>
<td>6.6 ± 10.9</td>
<td>1.3 ± 1.9</td>
<td>2.7 ± 0.4</td>
<td>64.9 ± 10.2</td>
<td>23.4 ± 7.5</td>
</tr>
<tr>
<td>Post SMS (mean ± SD)</td>
<td>99.3 ± 11.5</td>
<td>119.3 ± 14.6</td>
<td>20.0 ± 13.4</td>
<td>2.7 ± 2.2</td>
<td>1.9 ± 0.7</td>
<td>52.1 ± 17.2</td>
<td>18.2 ± 12.0</td>
</tr>
<tr>
<td>$p^b$</td>
<td>0.043</td>
<td>0.003</td>
<td>0.001</td>
<td>0.011</td>
<td>0.002</td>
<td>0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>

ARA = anorectal angle; KESS = Knowles—Eccersley—Scott Symptom.

$^a$ $p$ values obtained from Wilcoxon signed-rank test.

$^b$ Difference between rest and evacuation ARA.
and straining \((p = 0.003)\) during evacuation, the changes in perineal descent \((p = 0.011)\) when straining downward, and changes in the amounts of barium paste remaining in the rectum after evacuation \((p = 0.002)\) all reached significance following SMS intervention. The pre- and post-SMS bowel function of all patients showed significant decreases in the following items of the questionnaire: frequency of bowel movement \((p = 0.005)\), unsuccessful evacuation \((p = 0.018)\), and time needed for bowel hygiene \((p = 0.032)\) (Table 2).

### 4. Discussion

In this study, we demonstrated that SMS improved bowel elimination in elderly patients by means of enhancing CTT and harmonizing pelvic floor coordination to reach an adequate relaxation in the puborectalis and pelvic floor muscles during evacuation.

The two most commonly seen subtypes of primary constipation in the elderly are STC and PFD, with a less common subtype being irritable bowel syndrome with constipation.\(^{17}\) There are two pathophysiolgies that might be responsible for the STC.\(^{18,19}\) The first mechanism mainly involves the decreased frequency of high-amplitude propagating contractions from the proximal to a more distal part of the colon, particularly in the postprandial period. This phenomenon leads to impaired bowel movement and prolonged CTT in the elderly. In the second mechanism, the high-amplitude propagating contractions are not attenuated. Instead, the incidence of inappropriate and uncoordinated peristalsis increases, accompanied by poor propagation of bowel contents. An observation on age-related neurodegenerative changes revealed that up to 37% of normal neurons of the enteric nervous system were lost and then replaced by elastic and collagen fibers in the myenteric ganglia.\(^{20}\) Previous investigations have demonstrated that magnetic stimulation not only promotes colorectal motility, but also facilitates anal canal relaxation in some spinal cord injured patients.\(^{21,22}\) In our study, all patients have significant improvement in CTT and KESS scores, which is in concordance with the results of previous studies.\(^{21,22}\) Through releasing appropriate neurotransmitters, magnetic stimulation may modulate the myenteric plexus, ganglia, and interneuron connections to facilitate colon motility. The present study addresses the usefulness of SMS in facilitating hypoactive colon in elderly adults, as documented in improved CTT and KESS questionnaire scores.

PFD is characterized by difficulty with evacuation from the anorectum. It is believed to be caused by a failure of recto-anal coordination, either by paradoxical anal contraction or inadequate anal relaxation. Anorectal physiological changes, such as poor enlargement of the ARA and poor perineal descent, as demonstrated in this study, indicate the spasmodic puborectalis and deep pelvic floor muscles during defecation in elderly adults. This accentuates the flap-valve action of the ARA in blocking the passage of stool. Magnetic stimulation of the lumbosacral nerves in patients with puborectalis paradoxical syndrome led to rectal pressure elevation and balloon expulsion on rectal distension without significant change in the intragastric pressure.\(^{23}\) The polysynaptic sacral reflex can be reorganized through repetitive SMS, with a resulting reduction in sacral reflex latency.\(^{24}\) Magnetic conditioning can coordinate rectal and anal sphincter activities. We demonstrated in this study that SMS intervention allows the pelvic floor to relax considerably, which allows the rectum to descend and enables the ARA to increase during defecation.

Secondly, the enteric dysautonomia in elderly people may predispose them to develop geriatric gut dysfunction. In this regard, magnetic stimulation can modulate colorectal responses via large, myelinated afferent fibers in the sacral nerves to produce a somatovisceral reflex together with rectal contraction, which elicits a somatovisceral inhibitory reflex upon excessive splanchnic sympathetic activity.\(^{25}\) Furthermore, magnetic stimulation harmonizes pelvic floor somatic signals to coordinate the necessary contraction and relaxation during defecation. Moreover, when placing the magnetic coil at the thoracic spine and activating the corresponding innervated abdominal muscles, the penetrating magnetic force can result in massive abdominal contraction. The massage-like exercise may thus trigger enteric nervous system activity via pressure-sensitive nerves, make further transmissions to the central nervous system through the autonomic ganglia,\(^{26}\) and release excitatory neurotransmitters at the enteric neurons.

In comparison with other neuromodulatory methods, implanted sacral electrical stimulation or the surface sacral electrical stimulation have had some success in treatment of

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**Table 2**

Data summary of KESS questionnaire at baseline and post-SMS intervention.

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Baseline (mean ± SD)</th>
<th>Post-SMS (mean ± SD)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Laxative use</td>
<td>2.5 ± 0.9</td>
<td>2.2 ± 1.2</td>
<td>0.270</td>
</tr>
<tr>
<td>2. Frequency of bowel movement (using current therapy)</td>
<td>2.1 ± 1.4</td>
<td>1.5 ± 1.8</td>
<td>0.005*</td>
</tr>
<tr>
<td>3. Unsuccessful evacuation</td>
<td>2.5 ± 0.7</td>
<td>1.9 ± 1.1</td>
<td>0.018*</td>
</tr>
<tr>
<td>4. Feeling of incomplete evacuation</td>
<td>2.2 ± 1.4</td>
<td>2.2 ± 1.4</td>
<td>1.0</td>
</tr>
<tr>
<td>5. Abdominal pain</td>
<td>1.6 ± 2.0</td>
<td>1.7 ± 2.0</td>
<td>0.41</td>
</tr>
<tr>
<td>6. Bloating</td>
<td>2.0 ± 2.0</td>
<td>1.8 ± 2.0</td>
<td>0.332</td>
</tr>
<tr>
<td>7. Enema/digitations</td>
<td>1.9 ± 1.0</td>
<td>1.4 ± 1.6</td>
<td>0.091</td>
</tr>
<tr>
<td>8. Time taken (minutes at each evacuation/evacuation attempt)</td>
<td>2.3 ± 0.7</td>
<td>1.8 ± 1.0</td>
<td>0.032*</td>
</tr>
<tr>
<td>9. Difficult evacuation causing painful effort</td>
<td>2.9 ± 1.2</td>
<td>2.4 ± 1.3</td>
<td>0.19</td>
</tr>
<tr>
<td>10. Stool consistency</td>
<td>2.1 ± 1.3</td>
<td>1.7 ± 1.7</td>
<td>0.17</td>
</tr>
</tbody>
</table>

* Wilcoxon signed-rank test showed significant differences at \(p < 0.05\).

constipation, but also have considerable disadvantages.\textsuperscript{8,28} Implanting a neuroprosthesis requires surgery and has the risks of erection and ejaculation dysfunction (after dorsal rhizotomy). Researchers on surface electrical stimulation of sacral dermatomes have found that the stimulation does not lead to actual bowel emptying, but only an increase in the number of colonic spike waves.\textsuperscript{29} Therefore, SMS appears to be a safe and effective approach in the treatment of refractory constipation in comparison with other neuromodulatory methods.

The exact mechanisms through which SMS ameliorates geriatric bowel dysfunction remain inconclusive. To address the mechanisms of SMS, further investigation should be undertaken, including studies using immunofluorescent staining in animal models with different types of bowel dysfunction. The limitation of this study is that we did not design a randomized, double-blind controlled model. The patients we recruited had reached a stable bowel condition, chronic in nature, which would not improve with time. The intractable constipation of these patients was refractory to various medical treatments they had already tried during a considerable time span. Therefore, in our opinion, the before—after nature of this trial was valid, and its results were reliable. Nevertheless, to better confirm the reliability of the results achieved in this study, a placebo control group will be integrated into our next study.

In our own previous studies, we demonstrated that by carrying out the magnetic stimulation to the thoracic and lumbosacral spine, the mean CTT for spinal cord injured patients decreased significantly and the effect of this regimen could be carried over up to 3 months after treatment.\textsuperscript{10} In this study, the duration of efficacy of SMS was not measured in the elderly patients. However, in our experience, a lasting effect over 3 months in most of the patients was observed after SMS conditioning. A placebo-controlled study with long-term follow-up is warranted.

In conclusion, we have successfully demonstrated the usefulness of SMS in primary constipation of elderly adults. SMS of the thoracic and lumbosacral nerves can facilitate bowel movement and pelvic floor dysfunction. More active recruitment of the elderly in clinical trials is warranted to provide better evidence-based management. SMS should be available as a proper alternative and as a fundamental treatment in intractable constipation, and as a complementary technique with traditional therapies.

References