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Neurogenic bowel management after spinal cord injury: A systematic review of the evidence

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Abstract

OBJECTIVE—To systematically review evidence for the management of neurogenic bowel in individuals with spinal cord injuries (SCI).

DATA SOURCES—Literature searches were conducted for relevant articles, as well as practice guidelines, using numerous electronic databases. Manual searches of retrieved articles from 1950 to July 2009 were also conducted to identify literature.

STUDY SELECTION—Randomized controlled trials, prospective cohort, case-control, and pre-post studies, and case reports that assessed pharmacological and non-pharmacological intervention for the management of the neurogenic bowel in SCI were included.

DATA EXTRACTION—Two independent reviewers evaluated each study's quality, using the PEDro scale for RCTs and the Downs & Black scale for all other studies. Results were tabulated and levels of evidence assigned.

DATA SYNTHESIS—2956 studies were found as a result of the literature search. Upon review of the titles and abstracts, 52 studies met the inclusion criteria. Multi-faceted programs are the first approach to neurogenic bowel and are supported by lower levels of evidence. Of the non-pharmacological (conservative and non-surgical) interventions, transanal irrigation is a promising treatment to reduce constipation and fecal incontinence. When conservative management is not effective, pharmacological interventions (e.g., prokinetic agents) are supported by strong evidence for the treatment of chronic constipation. When conservative and pharmacological treatments are not effective, surgical interventions may be considered and are supported by lower levels of evidence in reducing complications.

CONCLUSIONS—Often, more than one procedure is necessary to develop an effective bowel routine. Evidence is low for non-pharmacological approaches and high for pharmacological interventions.

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INTRODUCTION

Neurogenic bowel is a colonic dysfunction resulting from a lack of central nervous control (see figure 1 for a schematic diagram of the GI tract). It is a syndrome commonly observed in individuals with spinal cord injury (SCI). Lynch et al.[1] assessed surveys from 467 persons with SCI and 668 age and gender-matched controls. They reported quality of life was affected by fecal incontinence in 62% of SCI respondents compared with 8% of controls. People with SCI suffered from greater extents of fecal urgency and required more time for bowel management. Coggrave et al.[2] assessed surveys from over a thousand individuals over a year post-SCI and reported the presence of constipation (39% of sample), hemorrhoids (36%) and abdominal distension (31%).

Neurogenic bowel dysfunction is a major physical and psychological problem for persons with SCI, as changes in bowel motility, sphincter control, coupled with impaired mobility and hand dexterity, result to make bowel management a major life-limiting problem. As bowel dysfunction following SCI is a major source of morbidity[3,4] it is not surprising that improving bowel function alone or bladder/bowel functions are rated among the highest priorities among individuals with SCI.[5,6]

There are two distinct patterns in the clinical presentation of bowel dysfunction: injury above the conus medullaris results in upper motor neuron (UMN) bowel syndrome and injury at the conus medullaris and cauda equine results in lower motor neuron (LMN) bowel syndrome.[7,8] The UMN bowel syndrome, or hyperreflexic bowel, is characterized by increased colonic wall and anal tones. Voluntary (cortical) control of the external anal sphincter is disrupted and the sphincter remains tight, thereby promoting retention of stool. The nerve connections between the spinal cord and the colon remain intact, and therefore, there is preserved reflex coordination and stool propulsion. The UMN bowel syndrome is typically associated with constipation and fecal retention at least in part due to external anal sphincter activity.[7] Stool evacuation in these individuals occurs by means of reflex activity caused by a stimulus introduced into the rectum, such as an irritant suppository or digital stimulation. LMN bowel syndrome, or areflexic bowel, is characterized by the loss of centrally-mediated (spinal cord) peristalsis and slow stool propulsion. LMN bowel syndrome is commonly associated with constipation and a significant risk of incontinence due to the atonic external anal sphincter and lack of control over the levator ani muscle that causes the lumen of the rectum to open. Completeness of injury also has a significant impact on bowel function in individuals with SCI. Those with an incomplete injury may retain the sensation of rectal fullness and ability to evacuate bowels so no specific bowel program may be required, however, the pathophysiologic mechanisms of fecal incontinence and constipation in subjects with incomplete SCI are similar to subjects with complete SCI and preserved spinal sacral reflexes.[9] Further, individual variations in bowel routing prior to SCI and preexisting conditions may also influence the pattern of bowel evacuation post injury. Careful evaluation and individual approaches are therefore important for accurate diagnoses and prescription of treatments for bowel management following SCI.

Successful bowel management is multi-dimensional, and as such, treatments may be multi-faceted, while others have focused on isolated strategies such as dietary, pharmacological, electrical stimulation and surgery. A systematic review of the evidence underlying bowel management has not been presented previously. The Consortium for Spinal Cord Medicine[10] provided guidelines for neurogenic bowel based on evidence and best practice, although they are now over a decade old. The following systematic review was therefore undertaken to evaluate the evidence that supports the efficacy and effectiveness of the various strategies used to manage neurogenic bowel complications. These findings are part of the Spinal Cord Injury Rehabilitation Evidence (SCIRE) project,[11] available at www.scireproject.com.

METHODS

A keyword literature search of articles, practice guidelines, and review articles was conducted to identify literature, published between 1950 and July 2009, evaluating treatments and therapies for neurogenic bowel in SCI populations. The key words of spinal cord injury, paraplegia and tetraplegia, were combined with neurogenic bowel, bowel management, incontinence, constipation, irregular, hemorrhoids, as well as treatment specific terms such as cisapride, colonic, colostomy, dietary fibre, laxative, and suppositories. Studies with SCI subjects as part of a mixed population sample were excluded if the results did not provide information specific to SCI.

Study quality was assessed by two independent reviewers. Randomized controlled trials (RCT) were evaluated with the Physiotherapy Evidence Database (PEDro).[12] PEDro is a 10 point score which assesses internal validity of a study, with higher scores indicating better methodological quality (9–10: excellent; 6–8: good; 4–5: fair; <4: poor).[13] A modified version of the Downs and Black evaluation tool was used to assess non-randomized studies. Scores on the modified Downs and Black tool range from 0 to 28, with higher scores also indicating a higher quality study. [14]

Levels of evidence developed by Sackett et al.[15] were modified and collapsed into 5 categories, where: Level 1 = RCT with a PEDro score ≥ 6; Level 2 = either a RCT with a PEDro score ≤ 5, non-randomized prospective controlled study, or cohort study; Level 3 = case-control study; Level 4 = either pre- and post-test or case-series; and Level 5 = either an observational report or case report involving a single subject or from clinical consensus.[14]

RESULTS

As a result of the literature searches through the electronic databases, 2956 articles were found that met the search criteria. After eliminating duplicates and then reviewing the titles and abstracts, a total of 52 studies evaluating neurogenic bowel management strategies met the inclusion criteria. Management strategies evaluated in this review are either of non-pharmacological (conservative and non-surgical), pharmacological, or surgical in nature. Twenty-five studies assessed non-pharmacological conservative management strategies, including multifaceted programs (three studies), suppositories (five studies), dietary fibre (one study), reflex stimulation (one study), abdominal massage (one study), assistive devices (two studies), irrigation techniques (six studies), and functional electrical stimulation of skeletal muscles (seven studies). Ten studies evaluated pharmacological treatment strategies, and seventeen studies on surgical interventions, including implantation of electrical stimulation systems (five studies), colostomy (nine studies), and the Malone procedure (three studies).

The following are the results for each type of management strategy.

Non-Pharmacological (Conservative and Non-surgical)

Multifaceted Programs—There are several factors that may influence bowel function including diet, fluid consumption, and routine bowel evacuations. Multifaceted programs target more than one factor in an attempt to reduce colonic transit time as well as decrease the incidences of difficult evacuations. Improving the movement of stool through the GI tract is the most important part of any bowel management protocol following SCI. An array of interventions, as components of a bowel routine, are recommended for the management of neurogenic bowel following SCI. These include dietary recommendations, anorectal/perianal stimulation, timing the performance of the bowel routine with food intake (thus taking advantage of gastro-colonic and recto-colonic reflexes), and a variety of pharmacological agents. Unfortunately, only a limited number of studies evaluated the effects of different protocols on bowel function following SCI.

There is level 4 evidence (from three pre-post studies; aggregate N=65)[16,17,18] that multifaceted bowel management programs reduce gastrointestinal transit time, incidences of difficult evaluations and duration of time required for bowel management (Table 1). Badiali et al.'s[16] multifaceted bowel management program effectively reduced gastrointestinal transit time while Correa and Rotter's[17] program reduced the incidence of difficult intestinal evacuation. Coggrave et al.[18] recently modified the bowel management program originally proposed by Badiali et al.[16] by including an additional step of manual evacuation and found a significant decrease in the number of bowel movement episodes requiring laxatives (from 62.8% to 23.1%). These authors also reported a significant decrease in the mean duration of bowel management episodes with the introduction of this protocol. As all three studies incorporated several factors into the bowel management programs including diet, fluid consumption, and routine bowel practice, it is not possible to determine the key factor.

Use of Suppositories—The use of chemical rectal agents (suppositories) is a common and often necessary component of a successful bowel management program. Bisacodyl (dulcolax) and glycerin are the most common active ingredients in these suppositories. Five studies (aggregate N =69)[19–23] examined the effect of suppositories on bowel management in SCI including one RCT and two controlled trials which were not randomized (Table 2). There is level 1 evidence (from 1 good quality RCT),[19] in addition to lower levels of evidence,[20–22] to support polyethylene glycol-based suppositories for bowel management. These suppositories resulted in a clinically significant decrease in the amount of nursing time for persons requiring assistance and less time to perform bowel care for the independent individual. The total bowel care time with the polyethylene glycol-based suppository is significantly less compared to hydrogenated vegetable oil-based bisacodyl suppositories.[21–23]

Dietary Fibre—There is level 4 evidence (from 1 case series; N=11)[24] that high fibre diets may cause colonic transit time to increase, rather than decrease (Table 3). Results of the one case series suggest that increasing dietary fibre in SCI patients does not have the same effect on bowel function as has been previously demonstrated in individuals with normal-functioning bowels. The effect may actually be the opposite of the desired result.[24] Therefore, adding more fibre alone does not improve bowel function.

Reflex Stimulation of the GI Tract—Digital rectal stimulation is often used as an adjunct to laxatives and enemas to facilitate bowel evacuation. There is level 4 evidence (from 1 pre-post study; N=6) (Table 4) that digital rectal stimulation increases motility in the left colon by activating preserved anorectal colonic reflexes.[25]

Abdominal Massage—There is level 4 evidence (from 1 pre-post study; N=24) that abdominal massage significantly shortened total colonic transit time, reduced abdominal distension and increased frequency of bowel movements per week (Table 5).[26] Ayas et al.[26] first established baseline values with 24 subjects who participated in a 3-week standard bowel program in which they received a standard diet containing 15–20 g of fiber/day and underwent daily digital stimulation. Patients then received at least 15 minutes of daily abdominal massage for a minimum of 15 days. The massage began at the cecum and extended along to the length of the colon to the rectum.

Assistive Devices—Assistive devices have been evaluated as means to improve bowel evacuation in individuals with SCI. These include a standing table and a modified toilet seat (2 studies, aggregate N=21) (Table 6). There is level 5 evidence (from 1 case report with one subject) that a standing table alleviates constipation in individuals with SCI.[27] Hoenig et al.[27] reported the case of an individual with SCI who, through the use of a standing table, doubled the frequency of his bowel movements and reduced time spent on bowel care. There is level 4 evidence (from 1 post-test study) that a washing toilet seat with visual feedback can reduce time spent on bowel care.[28] Uchikawa et al.[28] developed a new procedure to induce bowel movements using a toilet set equipped with an electronic bidet that provides water flow to the anorectal area. A camera and light are included to facilitate location of the anorectal area.

Irrigation Techniques—Six studies (aggregate N=445) evaluated irrigation techniques to improve bowel management (Table 7).[29–34] There is level 4 evidence (from 1 case series study evaluating 31 persons with SCI) that supports using pulsed water irrigation (intermittent rapid pulses) to remove stool in individuals with SCI.[29] There is also level 1 evidence (from 1 large good quality multi-site RCT with 87 subjects),[30] level 4 evidence (from 2 pre-post study evaluating 55 and 32 persons with SCI),[31,32] and level 5 evidence (from an observational study)[33] that support the use of the transanal irrigation (TAI) systems. In the RCT, the Peristeen Anal Irrigation system (Coloplast A/S, Kokkedal, Denmark), showed reduced frequency of lower urinary traction, improved fecal continence, and reduced constipation after 10 weeks of use when compared to the conservative bowel treatment (Paralyzed Veterans of America Clinical Practice Guidelines for Bowel Management).[30] Positive responses were greatest in the more severely impaired participants who used a wheelchair or were confined to bed (versus ambulatory participants). Findings were similar after 10 and three weeks of use in the two pre-post studies.[31,32] In the Del Popolo et al.[32] study, 9 out of 32 study subjects also either reduced or eliminated their use of pharmaceuticals. In the observational study, Faaborg et al.[33] found 98 of the 211 patients had successful outcomes after a mean follow-up of 19 months, and 74 patients were successfully using irrigation techniques after three years. In this study, successful outcomes were defined as irrigation still being used during follow-up, patients who used irrigation until they died, and patients whose symptoms had resolved while using irrigation techniques. Finally, there is level 4 evidence (from 1 retrospective review) that the Enema Continence Catheter can be used to treat the neurogenic bowel with improved fecal continence and improved quality of life[34] (see figure 2 for a diagram of the ECC).

Functional Electrical and Magnetic Stimulation of Skeletal Muscles—Six studies (aggregate N = 74) evaluated electrical or magnetic stimulation on skeletal muscles as a modality to improve colonic transit time in SCI with one study being an RCT (Table 8).[35–40]

There is level 1 evidence (from 1 good quality RCT) that external electrical stimulation of the abdominal wall muscles can improve bowel management for individuals with tetraplegia.[35] They used an overnight abdominal belt with embedded electrodes to provide the stimulus. Level 2 evidence also exists (from a prospective controlled trial), where 25 minutes of electrical simulation of the abdominal muscles per day, five days a week, for eight weeks, resulted in accelerated colonic transit times when compared to the placebo control group.[36] There is supporting lower evidence as Lin et al.[37,38] showed that the use of external abdominal functional magnetic stimulation reduced colonic transit time in individuals with SCI.

There is level 4 evidence (from 1 pre-post study with two subjects) that posterior tibial nerve stimulation improves bowel management for those with incomplete SCI.[39] While preliminary results for posterior tibial nerve stimulation appear promising, it is important to note that the statistical significance of the improvements in clinical and physiological parameters were not reported and the study involved only two subjects.[39] Level 4 evidence also exists for the use of functional magnetic stimulation on the thorax and lumbosacral nerves (simulation placed at T9 and L3 spinal processes) to reduce colonic transit times and self-reported symptoms of constipation.[40]

Pharmacological Agents

Ten studies (aggregate N =199) evaluated the effect of treatment strategies using pharmacology to enhance bowel management (Table 9).[41–50] These studies addressed the chronic constipation following SCI and used agents to promote transit through the GI tract. Of all the bowel management literature, studies involving pharmacological agents had the highest quality with 6 of the 10 studies being small, but good quality RCTs (PEDro≥6).

There is level 1 evidence (from 2 RCTs)[41,42] and level 2 evidence (from 1 RCT)[43] that cisapride significantly reduces colonic transit time for chronic constipation. There is also level 1 evidence (from 1 good quality RCT)[44] that prucalopride increases stool frequency, improves stool consistency and decreases gastrointestinal transit time. Prucalopride is a novel, highly selective serotonin receptor agonist with enterokinetic properties that facilitate cholinergic and excitatory non-adrenergic, non-cholinergic neurotransmission.[44] There is level 2 evidence (from 1 controlled trial which was not randomized; N=20)[45] that intravenous administration of metoclopramide corrects impairments in gastric emptying. Metoclopramide is a potent dopamine receptor antagonist with prokinetic properties and Segal et al.[45] found that impaired gastric emptying is correlated with decreased drug absorption. There is level 1 evidence (from 2 good quality RCTs)[46,47] in support of the use of neostigmine (a reversible cholinesterase inhibitor) or the combination of neostigmine and glycopyrrolate. When administered intravenously, Korsten et al.[46] found both neostigmine and the combination of neostigmine/glysopyrrolate to improve stool expulsion over normal saline. Similarly, Rosman et al.[47] found the combination to reduce total bowel evacuation time over placebo injections. There is level 1 evidence (from 1 good quality RCT with 71 participants) that fampridine (selective potassium channel blocker) can increase the number of days with bowel movements in approximately one-fifth of the subjects.[48]

Surgical Treatments

Implantation of Electrical Stimulation Systems—

Six studies (aggregate N = 71) evaluated the effects of surgical implantation of electrical stimulation systems (Table 10).[51–56] There is level 2 evidence (from 1 prospective, non-randomized controlled trial)[51] that support the use of sacral anterior root stimulation to reduce severe constipation in complete injuries. Binnie et al.[51] had found that an implanted Brindley stimulator did not reduce oro-caecal time for individuals with SCI. However, subjects in the stimulator group did experience a significant increase in defecation compared to the SCI group.

Furthermore, recent pre-post studies using sacral nerve root stimulation yielded improvements in bowel function, including the ability to evacuate spontaneously,[52] reduced bowel program times,[53] elimination of autonomic dysreflexia related to bowel management,[53] increased quality of life,[53] and elimination of manual help for defecation.[54] Similarly, level 4 evidence exists in support of sacral nerve stimulation in the treatment of faecal incontinence in patients suffering from cauda equine syndrome.[55] Gstaltner et al.[55] found an improved faecal continence, quality of life, and deliberate retention of faeces in all subjects.

There is level 4 evidence (from 1 pre-post study with results from only one subject presented) that the Praxis FES system for skeletal muscle stimulation paired with extradural electrodes for bowel and bladder stimulation increases the frequency of defecation and decreases time required for bowel care.[56]

Colostomy—A colostomy is the surgical formation of an artificial anus by connecting the colon to an opening in the abdominal wall. SCI patients who receive elective colostomy usually have exhausted all other medical treatments available to them for bowel management. Nine studies (aggregate N =590) examined the effect of colostomy after SCI (Table 11).[57–65] Given the ethical nature of this treatment (i.e., few safe options once they reach the point of requiring a colostomy), most studies are pre-post or retrospective in nature. There is level 4 evidence (from five studies),[56–60] and level 5 evidence (from one study)[64] that colostomy reduces the number of hours spent on bowel care. There is level 4 evidence (from 1 retrospective pre-post study)[57] that colostomy greatly simplifies bowel care routines. There is level 4 evidence (from 1 case study)[60] that colostomy reduces the number of hospitalizations caused by gastrointestinal problems and improves physical health, psychosocial adjustment and self-efficacy areas within quality of life. Similarly, level 4 and 5 evidence exists (from a post study and an observational study) that colostomy improves the independence, and thus quality of life, of SCI patients.[64,65]

The Malone Antegrade Continence Enema and the Enema Continence Catheter—The Malone Antegrade Continence Enema (MACE) is an approach using a surgically-created entry into the large intestine to irrigate the intestine (see figure 3). The procedure involves connecting the appendix to the abdominal wall and fashioning a valve mechanism that allows catheterization of the appendix, but avoids leakage of stool through it, thus forming an appendicostomy.[66] Consequently, a catheter can be introduced to the patient through the stoma and an enema administered.[34] Due to the wash-out effect and perhaps the stimulated colonic peristaltic, the colon and rectum will empty, thus preventing fecal incontinence and constipation.[34] Three retrospective studies (aggregate N=42) examined the effect of MACE on bowel function (Table 12).[34,67–68] There is level 4 evidence (from 3 retrospective reviews) that MACE successfully treats the neurogenic bowel and patients reported improvements including improved fecal continence, less time for bowel evacuation, reduced autonomic dysreflexia and improved quality of life.[34,67–68]

DISCUSSION

The management of bowel disorders, and in particular, the constipation that is so common in SCI patients, has remained essentially unchanged for several decades. This systematic review, however, has revealed some new areas of promise, including new assistive devices such as irrigation techniques and electrical stimulation.

This review identified 52 studies on neurogenic bowel management strategies. A multi-faceted approach is generally the first conservative approach to neurogenic bowel management which generally includes evacuation schedules, diet and fluid intake recommendations, as well as digital evaluation. As some form of multi-faceted approach is now standard of care, a trial which does not include some diet/fluid recommendations is not ethical. From the results of the three pre-post studies on multi-faceted bowel management, it is apparent that the protocols are highly individualized, and although there is generally a benefit, the results can be varied among participants.

Coggrave et al.[2] reported that digital evacuation was the most common intervention (reported by 56% of the 1334 participants with SCI). One study[25] showed that digital rectal stimulation increases peristaltic waves in the left colon, thus increasing motility in this segment. Gastro-colonic and ano-rectal reflexes can be successfully incorporated into a bowel routine for individuals with SCI. It is well-known that following breakfast, a gastric distention can activate bowel motility and morning defecation.[69,70] Furthermore, digital ano-rectal stimulation has been shown to be useful in bowel evacuation following spinal cord injury,[71] and is potentially useful in bowel management following SCI. At least in part, an anorectal colonic reflex that results in enhanced contractions of the descending colon and rectum may contribute to bowel evacuation in individuals with SCI. Stimulation via abdominal massage appears to have some promising outcomes on colonic function, and controlled trials are feasible for this intervention and need to be done.

Conservative treatment may also include diet, although the study by Cameron et al.[24] sends a cautionary message that dietary fibre may have different effects in people with SCI compared to able-bodied persons. Therefore, adding more fibre alone does not improve bowel function.

Clinical experience shows that despite their best efforts, some persons with SCI are unable to achieve an effective, regular bowel routine and thus, other methods may be explored. Pulse water irrigation is one promising technique and consists of supplying intermittent, rapid pulses of warm water into the rectum to break up stool impactions and to stimulate peristalsis.[29] Pulsed irrigation evacuation is a safe and effective method for individuals with SCI who develop impactions or do not have an effective bowel routine.[29] The one large, multi-site RCT showed that transanal irrigation reduces time spent on bowel management, dependency on others for help, and the frequency of defecation-related symptoms (i.e. abdominal pain, anorectal pain, nausea).[30] In addition, transanal irrigation appears to alleviate fecal incontinence and constipation more so than conservative bowel management.[30]

Electrical or magnetic stimulation devices can be expensive, and are not readily accessible to patients. These devices generally have weak evidence. The exception was the stimulation which used an abdominal belt with embedded electrodes and resulted in reduced bowel time.[35]

Often, medication is considered a later resort (although prior to surgery), with its use reserved for persons with severe constipation and where modification of the conservative bowel program has failed. Prokinetic agents are presumed to promote transit through the GI tract, thereby decreasing the length of time needed for stool to pass through the intestines and increasing the amount of stool available for evacuation. Pharmacological studies were high quality (good quality RCTs) with positive results for Cisapride (the most commonly used), prucalopride, metoclopramide, neostigmine (administered both with and without glycopyrrolate), and fampridine. Chemical rectal agents (suppositories) are used commonly by persons with SCI to maintain or enhance a successful bowel management program. The glycerin suppository is a mild local stimulus and lubricating agent. Bisacodyl (dulcolax) is an irritant that acts directly on the colonic mucosa producing peristalsis throughout the colon. The most commonly used laxative suppositories contain 10 mg of bisacodyl powder distributed within a hydrogenated vegetable-oil base (HVB).[19] However, polyethylene glycol-based suppositories appear to be more effective than those in hydrogenated vegetable oil-based bisacodyl supporities.[20–22]

Because conservative or pharmacological management of neurogenic bowel dysfunction is successful in 67% of the SCI population,[72] surgical interventions provide an option for those with severe chronic constipation or when conservative management fails. Surgical interventions such as implantation of electrodes, colostomies, and the MACE procedure are options to treat chronic severe constipation when conservative management is ineffective. While no studies have determined the best time to reevaluate the effectiveness of conservative management strategies, one year post injury is likely a good time to determine if surgical interventions will provide better outcomes.[72] Han et al.[73] report 93% of individuals have a stable bowel management status 12 months post SCI, and similarly, Lynch et al.[1] report that after 12 months, bowel function does not change significantly with time or age.

The outcomes from implanted electrical stimulation techniques (implantation of epineural electrodes for skeletal muscle activation, and implantation of epidural or anterior sacral root electrodes) requires consideration as the participants in these trials are most often individuals who do not respond well to conservative management and/or have a history bowel complications.[40] Thus, any improvements from this select group might be viewed with encouragement, given their lack of response to other treatments. Because of the invasiveness of these surgical procedures, control groups were not included in the implanted stimulator studies. However, in the future studies, investigators should be encouraged to randomize participants once implanted with the electrodes into a period of “on-stimulation” versus “off-stimulation”. Such a design would permit interpretation of potential placebo effects of the surgery and instrumentation.

The need for colostomies and the MACE are often viewed as a failure of rehabilitation services. However, it is of importance to note that colostomy is a safe, effective method of managing severe and chronic GI problems, and perianal pressure ulcers in persons with SCI. Our systematic review shows that colostomies reduce the number of hours spent on bowel care,[57–61] reduces the number of hospitalizations caused by GI problems,[60] and bowel care-related complaints,[57] simplifies bowel care routine,[57] and improves quality of life.[59,60,64] In addition, many patients wished to have the colostomy done earlier.[61] As described by Safadi et al.,[65] the left colostomy may be preferred because it preserves colic surfaces to absorb water and prevent dehydration, thus, feces are less liquid and discharges less frequent than with right colostomies. Using a decision analysis to examine the optimal treatment for chronic refractory constipation in SCI, Furlan et al.,[72] found that the MACE procedure had the best long term outcomes (reduced complication rates, lower incidence of autonomic dysreflexia, and fitted with patient preferences). As more data becomes available, however, results could change upon further critical evaluation of the impact of surgical interventions on the patient’s well-being.

CONCLUSION

Multi-faceted bowel management programs are the first approach to neurogenic bowel programs and are supported by lower levels evidence (pre-post studies). Often, more than one procedure is necessary for individuals that are unable to develop an effective bowel routine. Digital rectal stimulation is often incorporated within these multi-faceted programs and increases motility in the left colon in individuals with SCI. Diet and fluid intake are important components of multi-faceted bowel management programs, although there is a need for further research to examine the optimal level of dietary intake in spinal cord injured patients. Transanal irrigation is a promising technique to reduce constipation and fecal incontinence. When conservative management is not effective, prokinetic agents such as cisapride, prucalopride, metoclopramide, neostigmine, and fampridine are supported by strong evidence for the treatment of chronic constipation in persons with SCI. Surgical interventions such as colostomy, MACE and implanted stimulators are not routinely used, although all are supported by lower levels of evidence (pre-post studies) in reducing bowel-related complications and improving quality of life.

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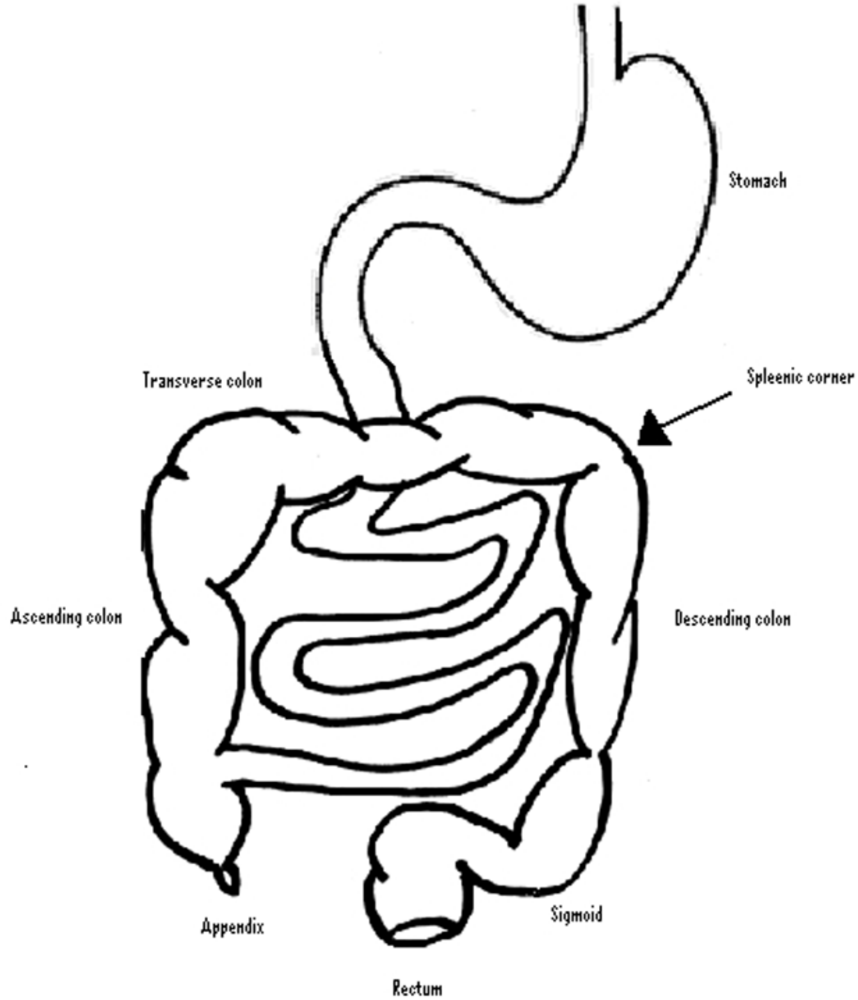

Figure 1. Schematic diagram of the GI Tract

Parasympathetic innervation is provided by the Vagus (CNX) from the esophagus to the spleenic corner of the large intestine. Innervation of the GI tract after the spleenic corner is provided by the sacral part of the parasympathetic nervous system (S2 – S4). Sympathetic innervation to the upper GI tract is provided by the SPNs localized within the upper thoracic spinal segment (T1–T5); the small and a large intestine are controlled by SPNs localized within the T6–T12 spinal segments.

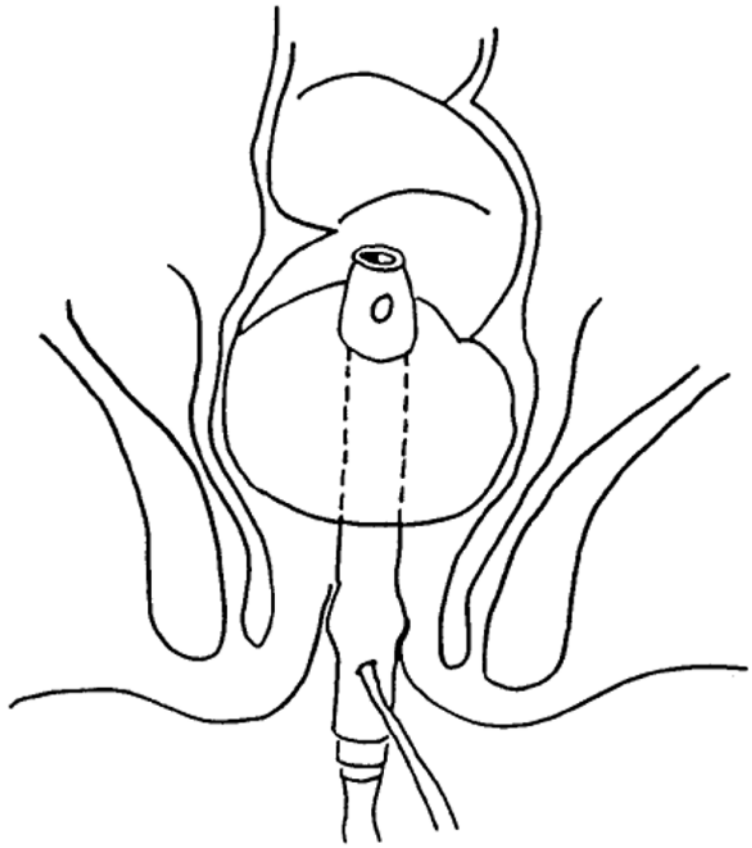

Figure 2. Schematic diagram of the Enema Continence Catheter

A catheter is inserted into the rectum and a balloon is inflated to hold the catheter in place during the administration of an enema. After installing the enema, the balloon is deflated, the catheter is removed, and the bowel content will empty.

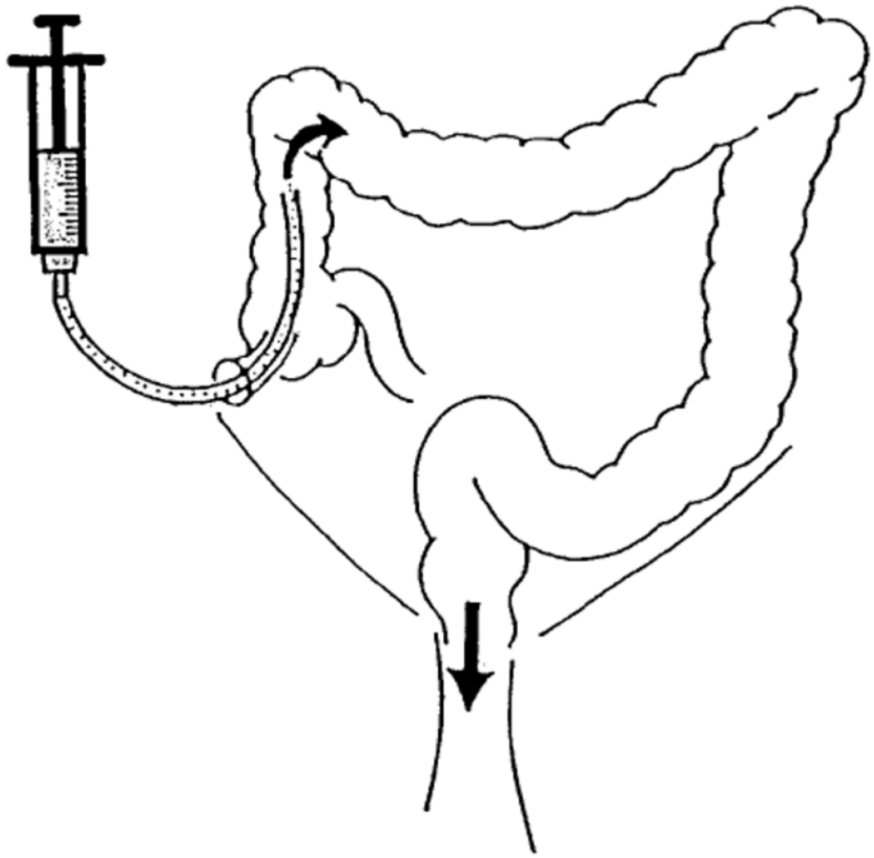

Figure 3. Diagram of the Malone Anterograde Continence Enema (MACE)

The MACE procedure involves a surgical operation to bring out the appendix through the skin thereby forming an appendicostomy. An enema may be introduced through the abdominal wall stoma. The enema produces a wash-out effect and stimulates colon peristalsis, which then evacuates the contents in the colon.

Table 1

Multifaceted Programs

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
Coggrave et al. 2006;[18] United Kingdom Downs & Black score=17 Pre-post N=17	**Population:** Mean age: 41.24 years, range 19–59; Level of injury: 8 cervical; 8 thoracic, and conus medularis; motor compete. **Treatment:** Modified progressive bowel management protocol designed by Badiali et al. (1997) **OM:** Number of episodes requiring laxative and duration of bowel management episodes.	**1** Protocol increased successful bowel management episodes without the use of laxatives and decreased episodes requiring laxatives. **2** Duration of bowel management episodes decreased as did the number of episodes requiring manual evacuation.
Correa & Rotter 2000;[17] Chile Downs & Black score=13 Pre-post N=38	**Population:** Age range=19–71; 21 complete, 10 incomplete; 2/21 tetraplegic and 19/21 paraplegic. **Treatment:** Intestinal program administration **OM:** DIE scale; GI symptoms.	**1** DIE reduced from 26.5% to 8.8%, GI symptoms, and manual extraction reduced from 53% to 37%.
Badiali et al. 1997;[16] Italy Downs & Black score=13 Pre-post N=10	**Population:** Mean age: 33 years, range 20–60; Level of injury: C3-L4. **Treatment:** Modified diet, water intake, and evacuation schedule. **OM:** bowel movement frequency, CTT.	**1** Bowel frequency increased at the end of training. **2** Reduction in gastrointestinal transit time.

OM = Outcome measures; CTT = Colonic transit time; DIE = Difficult Intestinal Evacuation; GI = gastrointestinal

Table 2

Suppositories

Author Year; Country Score Research Design Total Sample Size	**Methods**	**Outcome**
House & Stiens 1997;[19] USA PEDro=7 RCT N=15	**Population:** Mean age: 45, range 26–61; Level of injury: 9 cervical, 6 thoracic, 11 complete, 4 incomplete. **Treatment:** 10mg HVB or 10mg PGB. **OM:** time to flatus, flatus to stool flow, defecation period	**1** PGB significantly less time than HVB. **2** No significant differences in flatus to stool flow. **3** PGB suppositories significantly decreased bowel care time.
Stiens et al. 1998;[22] USA Downs & Black score=18 Non-randomized cross-over controlled N=14	**Population:** Mean age: 53.4 years; Level of injury: C3-L1, 4 incomplete, 10 complete. **Treatment**: PGB or HVB suppositories **OM:** Time to flatus; flatus to stool flow; defecation period; clean up; total bowel care time.	**1** Time to flatus: HVB=31 min, PGB=12 min; Defecation period: HVB=58 min, PGB=32 min; Total bowel care time: HVB=102 min, PBG=51.2 min. **2** Digital stimulations required for the bowel care sessions: HVB=5.0, PGB=3.2.
Frisbie 1997;[21] USA Downs & Black score=16 Prospective controlled trial N=19	**Population:** Age: mean 64 years, range 41–81; Level of injury: 15 cervical and 4 thoracic (T1-7), 15 motor complete. **Treatment:** PGB or HVB **OM:** Average time for complete bowel evacuation.	**1** All patients experienced a shortening of bowel care time with PGB. Average time for bowel evacuation was 2.4 hours with HVB, 1.1 hours with PGB.
Dunn & Galka 1994;[20] USA Downs & Black score=12 Case Series N=14	**Population:** Age range: 27–67; Level of injury: C5-L1, 5 tetraplegics, 9 paraplegics. **Treatment:** Bisacodyl and Theravac SB. **OM:** bowel management time; bowel problems.	**1** Mean evacuation times were lower with the use of Theravac SB than with Bisacodyl.
Amir et al. 1998;[23] USA Downs & Black score=9 Cohort N=7	**Population:** Age range: 21–76; Level of injury: C4-T12, 6 tetraplegics, 1 paraplegic. **Treatment:** One week of therapy with one of the following: 1) two bisacodyl; 2) two glycerin; 3) one mineral oil enema; or 4) one Theravac SB. **OM:** Total colonic and segmental CTT.	**1** Total CTT significantly reduced with Theravac SB, no significant difference between Theravac SB and mineral oil enema but both had significantly shorter CTT than bisacodyl or glycerin. **2** Theravac SB had the shortest CTT and was best for symptom reduction.

OM = Outcome measures; HVB = hydrogenated vegetable-oil base; PBG = polyethylene glycol base; CTT = Colonic transit time

Table 3

Dietary Fibre

Author Year; Country **Score** **Research Design** **Total Sample Size**	**Methods**	**Outcome**
Cameron et al. 1996;[24] Australia Downs & Black score=10 Case Series N=11	**Population:** Age range: 19–53yrs; Level of injury: C4-T12; 1 incomplete and 10 complete; 7 tetraplegics and 4 paraplegics. **Treatment:** Increased fibre intake (40g Kellogg's All Bran). **OM:** Stool weight, CTT and segmental transit time, bowel evacuation time and fibre intake.	**1** Fibre intake increased from 25g to 31g per day. **2** Mean CTT increased from 28.2 hours to 42.2 hours. **3** Rectosigmoid CTT increased from 7.9 to 23.3 hours. **4** No change in stool weight and evacuation time.

OM = Outcome measures; CTT = colonic transit time

Table 4

Reflex Stimulation

Author Year; Country Score Research Design Total Sample Size	**Methods**	**Outcome**
Korsten et al. 2007;[25] USA Downs & Black score=12 Pre-post N=6	**Population:** Mean age: 50.2, range 44–50; Level of injury: C5-T10; 4 paraplegics, 2 tetraplegics. **Treatment:** DRS **OM:** Colorectal monometry: mean number of peristaltic waves per minute; amplitude of contractions; colonic motility	**1** Increase in peristaltic waves/min during DRS (1.9±0.5/min) and after DRS (1.5±0.3/min) average amplitude was 43.4±2.2 mmHg (range 0.7–250). **2** Peristaltic contractions in the left colon were accompanied by increased motility.

OM = Outcome measures; DRS = digital rectal stimulation

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Table 5

Abdominal Massage

Author Year; Country **Score** **Research Design** **Total Sample Size**	**Methods**	**Outcome**
Ayas et al. 2006;[26] Turkey Downs & Black score=18 Pre-post N=24	**Population:** Mean age: 39.8, range 33.1–46.6; Level of injury: C4 to L3; 15 complete; 9 incomplete. **Treatment:** Abdominal massage from the cecum to the rectum. **OM:** CTT, frequency of defecation.	**1** Mean frequencies of defecation increased from 3.79±2.15 to 4.61±2.17 per week. **2** CTT decreased from 90.60±32.67 hours to 72±34.10 hours.

OM = Outcome measures; CTT = colonic transit time

Table 6

Assistive Devices

Author Year; Country Score Research Design Total Sample Size	**Methods**	**Outcome**
Hoenig et al. 2001;[27] USA Downs & Black score=15 Case Report N=1	**Population:** 62-year-old male with T12-L1, paraplegia. **Treatment:** Standing table, 5 times/week. **OM:** Frequency of bowel movements and length of bowel care episodes.	**1** Bowel movements increased from 10 to 18. **2** The time spent on bowel care reduced from 21 to 13 minutes.
Uchikawa et al. 2007;[28] Japan Downs & Black score=13 Post-test N=20	**Population:** Mean age: 46.3, range 18–73; Level of injury: 11 cervical, 7 thoracic, 2 lumbar. **Treatment:** toilet seat equipped with an electronic bidet, a light, and camera monitor. **OM:** Time for bowel movement, residual stool.	**1** 75% (15 subjects) of participants decrease time of bowel routine to less than 30 min compare to only 35% (7 subjects) with usual bowel care.

OM = Outcome measures

Table 7

Irrigation Techniques

Author Year; Country **Score** **Research Design** **Total Sample Size**	**Methods**	**Outcome**
Christensen et al. 2006;[30] Denmark PEDro score=7 Randomized control trial N=87	**Population:** TAI group: mean age: 47.5; Level of injury: T10- S1, 23 complete and 12 incomplete. Conservative management group: Mean age: 50.6 years; T10-S1, 23 complete and 22 incomplete. **Treatment:** TAI (Peristeen Anal Irrigation system) or conservative management (PVA clinical guidelines) for 10 weeks. **OM:** CCCSS, FIGS, fecal incontinence score.	**1** TAI group scored better on symptom-related quality-of-life tool, CCCSS, FIGS, and NBD. **2** Improvement found in the TAI group was not confined to the more physically able patients. **3** The frequency of urinary tract infection was lower in the TAI group.
Christensen et al. 2008;[31] USA Downs & Black score = 20 Pre-Post N = 55	**Population:** Mean age 47.5 ± 15.5; Level of injury: 61 supraconal, 37 complete, 25 incomplete **Treatment:** TAI (Peristeen Anal Irrigation) for 10 weeks **OM:** CCCSS; FIGS; and NBD.	**1** CCCSS, FIGS and NBD scores improved. **2** TAI significantly reduced constipation, improved anal continence, and improved symptom-related QoL.
Christensen et al. 2000;[34] Denmark Downs & Black score=17 Retrospective interviews and case series N=29; 19 SCI patients	**Population:** ECC group: Mean age: mean 39.9, range 7–72; Level of injury: T2–T11, conal or cauda equina injuries (n=15). MACE group: Mean age: 32.8, range 15–66; Level of injury: C5-T2 (n=4). **Treatment:** ECC vs. MACE **OM:** colorectal function, practical procedure, impact on daily living and QoL, general satisfaction	**1** The ECC was successful in 53% of participants (8 subjects) **2** The MACE procedure was successful in 75% of participants (3 subjects). **3** Successful treatment with the ECC or the MACE led to significant improvements in QoL.
Del Popolo et al. 2008;[32] Italy Downs & Black score = 14 Pre-Post N = 32	**Population:** Median age: 31.6, 13 complete, 14 incomplete **Treatment:** TAI (Peristeen Anal Irrigation) for a 3 weeks **OM:** QoL; use of pharmaceuticals; incidence of incontinence and constipation; abdominal pain or discomfort	**1** Significant increase in QoL scores and improvement of constipation. **2** Significant decrease in abdominal pain and incidence of incontinence. **3** Nine patients reduced or eliminated pharmaceutical use.
Faaborg et al. 2008;[33] Denmark Downs & Black score = 13 Observational N = 211	**Population:** Median age 49, range 7–81; Etiology: 74 traumatic, 32 spinal bifida, 29 prolapsed intervertebral disk, 38 other, 38 non-SCI. **Treatment:** TAI **OM:** Rate of success (treatment was successful if: 1) currently using TAI; 2) the patient used TAI until death; or 3) symptoms resolved while using TAI)	**1** 42 patients stopped TAI in the first 3 months. **2** Success in 98 patients after 19 months; and 73 patients after 3 years of follow up. **3** Abdominal pain, minor rectal bleeding, and general discomfort were observed in 101 patients.
Puet et al. 1997;[29] USA Downs & Black score=12 Case Series N=31	**Population:** Age: n/a; Level of injury: 8 tetraplegic, 4 complete; 23 paraplegic, 9 complete. **Treatment:** Pulsed irrigation **OM:** Efficacy of technique, outpatient use.	**1** Success in removing stool in all but three patients. **2** Eleven patients had multiple procedures.

OM = Outcome measures; TAI = transanal irrigation; CCCSS = Cleveland Clinic Constipation Scoring System; FIGS = St Mark's Fecal Incontinence Grading System; NBD = neurogenic bowel dysfunction; QoL = quality of life; PVA = Paralyzed Veterans of America; ECC = Enema continence catheter; MACE = Malone antegrade continence enema.

Table 8

Functional Electrical and Magnetic Stimulation of Skeletal Muscles

Author Year; Country Score Research Design Total Sample Size	**Methods**	**Outcome**
Korsten et al. 2004;[35] USA PEDro=6 RCT N=8	**Population:** Mean age: 48, range 34–62 years; 6 tetraplegics, 2 paraplegics. **Treatment:** Abdominal belt with embedded electrodes, used for 6 bowel care sessions over 2 weeks. Subjects did not know whether the device was activated or not. **OM:** Time to first stool, time for total bowel care.	**1** Activation of the abdominal belt significantly reduced the time to first stool and time for total bowel care. **2** Time to first stool and time for total bowel care was significantly shortened in 6 subjects with tetraplegia, but not in the 2 subjects with paraplegia.
Hascakova-Bartova et al. 2008;[36] Belgium Downs & Black score = 21 Prospective Controlled Trial N = 10	**Population:** Mean age: 42, range 23–61; Level of injury C3-T10. **Treatment:** Abdominal NMES, administered for 25 minutes per day, 5 days a week, for 8 weeks **OM:** EMG; FVC; CTT	**1** NMES decreased FVC in the treatment group but not in the control group. **2** NMES accelerated CTT in the ascending, transverse, and descending colon.
Lin et al. 2001;[37] USA Downs & Black score=12 Pre-post N=15	**Population:** Mean age: n/a; Level of injury: C3-L1 **Treatment:** Protocol 1: FMS on the transabdominal and lumbosacral regions. Protocol 2: 5-week stimulation period. **OM:** Rectal pressure and total and segmental transit times.	**1** Rectal pressures increased with sacrolumbar stimulation, and with transabdominal stimulation. **2** The mean CTT decreased from 105.2 to 89.4 hours after 5 week of stimulation.
Lin et al. 2002;[38] USA Downs & Black score=11 Pre-post N=9	**Population:** Mean age: 42; Level of injury: C3–C7 (n=4) and 5 able bodied controls. **Treatment:** FMS along T9 spinous process. **OM:** Rate of gastric emptying.	**1** Gastric emptying half/time of post-stimulation was significantly shorter in SCI subjects than the baseline (84±11 min versus 59±13 min). **2** There was also a significant improvement in the percentage of gastric emptying with FES at 20, 60, 90 and 120 min in compression at baseline.
Tsai et al. 2009;[40] Taiwan Downs & Black score = 19 Pre-Post N = 22	**Population:** Mean age: 46.7, range 22–65). **Treatment:** FMS of the thorax and lumbosacral nerves, in 20-minute sessions twice daily for 3 weeks. **OM:** CTT; Knowles-Eccersley- Scott Symptom Questionnaire	**1** Mean CTT decreased from 62.6 h to 50.4 h **2** Mean scores on the Knowles- Eccersley-Scott Symptom Questionnaire decreased from 24.5 to 19.2 points
Mentes et al. 2007;[39] Turkey Downs & Black score=13 Pre-post N=2	**Population:** 51-year-old woman (discectomy for lumbar disc herniation), and a 31-year-old man (10-year history of lumbar cavernous haemangioma). **Treatment:** 30 minutes of tibial nerve stimulation every other day for 4 weeks, then repeated every 2 months for 3 times. **OM:** physiologic, clinical and QoL parameters.	**1** Patients showed improvements in Wexner FI score, FIQL score, clinical parameters and physiological measurements. Significance of improvements not reported in this study.

OM = Outcome measures; NMES = neuromuscular electrical stimulation; EMG = Electromyography; FVC = Forced vital capacity; CTT = colonic transit times; n/a = information not available; FMS = functional magnetic stimulation; FIQL = faecal incontinence quality of life scales; QoL = quality of life

Table 9

Pharmacological Agents

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
Rosman et al. 2008;[47] USA PEDro = 8 RCT N = 7	**Population:** Mean age 46.9, range 30 – 56 yrs; Level of injury: cervical and thoracic. **Treatment:** Injections of neostigmine and glycopyrrolate for 1 week, wash-out period for 1 week, and placebo for 1 week. **OM:** Total bowel evacuation time; time to first flatus, beginning of stool flow, end of stool flow.	**1** Injections significantly reduced total bowel evacuation time, time to first flatus, time to beginning and end of stool flow.
Geders et al. 1995;[42] USA PEDro=8 RCT N=9	**Population:** Mean age: SCI group 58.8; Controls 63.4; 2 paraplegics, 7 tetraplegics **Treatment:** Cisapride or placebo administered in oral doses. **OM:** CTT, questionnaire on type, frequency, and severity of clinical symptoms.	**1** CTT was significantly longer in SCI group. **2** Subjects with a normal CTT demonstrated no benefit to the administration of cisapride. **3** Five quadriplegic subjects with initial abnormal total CTT improved their left CTT following treatment.
Rajendran et al. 1992;[41] USA PEDro=8 RCT N=14	**Population:** Age range: 19–71; Level of injury: C4-L2; 7 tetraplegics and 7 paraplegics. **Treatment:** Oral administration of cisapride four times per day for four days, and placebo. **OM:** Gastric emptying or MCTT.	**1** No delay or improvement in gastric emptying was observed after the administration of cisapride. **2** Cisapride resulted in normalization of the tetraplegic subjects' MCTT.
Krogh et al. 2002;[44] Denmark PEDro=7 RCT N=22	**Population:** Mean age: 34.7 (placebo group), 36.5 (1mg group), 44.3 (2mg group). **Treatment:** Prucalopride 1mg or placebo, taken once daily for four weeks; and Prucalopride 2mg or placebo for four weeks. **OM:** Constipation; urinary habit; constipation severity and symptoms; CTT.	**1** Constipation severity increased with placebo; decreased with prucalopride. **2** Improvement in frequency of bowel movements over 4 weeks in the 2 mg group. **3** Four patients (2 mg group) reported moderate/severe abdominal pain.
Korsten et al. 2005;[46] USA PEDro score=6 RCT N=13	**Population:** Mean age: 46; range 25–69; Level of injury C4-T12; 5 tetraplegic, 8 paraplegic, 12 motor complete, 5 sensory complete. **Treatment:** Normal saline, 2 mg neostigmine, or combination of 2 mg neostigmine and 0.4 mg glycopyrrolate. **OM:** Bowel evacuation.	**1** Normal saline was least effective for bowel evacuation. **2** Mean time to evacuation was 11.5 min after neostigmine and 13.5 min after the combination of neostigmine and glycopyrrolate.
Cardenas et al. 2007;[48] USA PEDro score=6 RCT N=91	**Population:** Group 1: Mean age: 44, range 23–66; Group 2: Mean age: 42, range 21–67; Group 3: Mean age: 38, range 19–61; Level of injury: 73 cervical, 18 thoracic. **Treatment:** 8 weeks; group 1: Fampridine, sustained release, 25 mg twice a day; group 2: 40 mg twice a day; group 3: Placebo. **OM:** Number of days with bowel movement.	**1** Significantly larger number of subjects in groups 1 and 2 had an increase in the number of days with bowel movements compared to subjects in the placebo group. Number of days increase not reported.
De Both et al. 1992;[43] Netherlands PEDro score=5 RCT N=10	**Population:** Mean age: 35.8, range 19–63; Level of injury: C6-L1. **Treatment:** Group 1: Cisapride 10 mg four times daily; Group 2: placebo **OM:** Defecation frequency, consistency of stools, percentage of defecations preceded by digital stimulation or suppository, CTT	**1** No difference in number of defecations per week. **2** Significant improvement in ease of evacuation in both the cisapride and placebo, and reduction in CTT with cisapride. **3** Consistency of stools changed significantly with cisapride.

Author Year; Country Score Research Design Total Sample Size	**Methods**	**Outcome**
		4 Cisapride and placebo had no effect on digital reflex stimulation or suppository use.
Binnie et al. 1988;[49] UK Downs & Black score=12 Pre-post N=10	**Population:** Mean age: 34.1, range 20–45yrs; Level of injury: C4-T10, all complete. **Treatment:** Intravenous injection of 10 mg cisapride. After at least 48 hours subjects were administered cisapride orally. **OM:** CTT.	**1** CTT was reduced from 185±86.3 to 123±77.0 hours.
Longo et al. 1995;[50] USA Downs & Black score =9 Pre-post N=15	**Population:** Mean age: n/a; Level of injury: 12 tetraplegics, 3 paraplegics. **Treatment:** 20mg cisapride, three times per day for one month. **OM:** Anorectal manometry; bowel movements; intestinal transit time.	**1** 6/12 had improved symptoms of constipation. 9/12 had reduced the time needed for a bowel movement. **2** No worsening of constipation. **3** 6/12 had a 10% or more increase in resting anal canal pressure.
Segal et al. 1987;[35] USA Downs & Black score=9 Prospective Controlled Trial N=20, Control N=8	**Population:** Age range 20–55; Level of injury: 11 tetraplegic, 9 paraplegic, all complete. **Treatment:** Liquid meal, then within 2 weeks, ingested 2nd liquid meal with intravenously administered metoclopramide. **OM:** Half time of gastric emptying, GE patterns in the early and later phases.	**1** Mean GE half time for a liquid meal decreased in the quadriplegic subjects from 104.8 min to 18.8 min after treatment. **2** In the paraplegic subjects, a pretreatment mean GE of 111.5 min decreased to 29.1min.

OM = Outcome measures; CTT = Colonic transit time; MCTT = mouth to cecum transit time; GE = gastric emptying

Table 10

Implanted Electrical Stimulation Systems

Author Year; Country **Score** **Research Design** **Total Sample Size**	**Methods**	**Outcome**
Chia et al. 1996;[52] Singapore Downs & Black score=14 Pre-post N=8	**Population:** Mean age: 40, range 20–53 years; Level of injury: C4-T11. **Treatment:** Implantation of anterior sacral roots electrodes. **OM:** Bowel frequency, laxative use, suppository use, need for digital evacuation, anorectal monometry	**1** 6 patients had improved bowel function: 4 were able to evacuate spontaneously after stimulation **2** The 6 patients with improved bowel routine also showed a positive rectoanal pressure difference immediately after stimulation.
Kachourbos & Creasey 2000;[53] USA Downs & Black score=12 Pre-post N= 16	**Population:** Patients with a history of bowel complications **Treatment:** Implantation of sacral roots electrodes (S1–S3) with rhizotomy. **OM:** Bowel program times; QoL.	**1** Bowel program times were reduced from 5.4 hours per week to 2.0 hours. **2** Subjects had an overall improvement in QoL.
Gstaltner et al. 2008;[55] Austria Downs & Black score = 11 Pre-Post N = 11	**Population:** Mean age: 46; Level of injury: n/a **Treatment:** Implantation of sacral roots electrodes **OM:** The Wexner Score for faecal continence; QoL.	**1** Five subjects had permanent implantations. **2** Improved faecal continence, deliberate retention of faeces, and perianal sensitivity in all five subjects. **3** Improved quality of life.
MacDonagh et al. 1990;[54] UK Downs & Black score=10 Pre-post N=12	**Population:** Mean age: 33, range 21–49; Level of injury: 10 thoracic, 2 cervical, all complete. **Treatment:** Implanted Brindley-Finetech intradural sacral anterior root stimulator **OM:** Full defecation	**1** Six patients achieved full defecation. **2** Reduced time to complete defecation. **3** All were free from constipation.
Binnie et al. 1991;[51] UK Downs & Black score=8 Prospective Controlled Trial N=27	**Population:** Group 1: Mean age: 29.1, range 22–38; non-SCI. Group 2: Mean age: 34.1, range 20–45; Level of injury C4-T10; Group 3: Mean age: 36.3, range 20–50; Level of injury: C5-T3. **Treatment:** Brindley anterior sacral root stimulator implanted in Group 3. **OM:** CTT, fecal water content, and frequency of defecation.	**1** No significant difference in CTT between all groups. **2** Group 3 had a significant increase in defecation frequency versus group 2.
Johnston et al. 2005;[56] USA Downs & Black score = 14 Pre-post N=3; however, only 2 had neurogenic bowel outcome measures and results presented only for 1	**Population:** Age range: 17–21; Level of injury: T3–T8, complete. **Treatment:** Stimulation of skeletal muscles for upright mobility. Two subjects also received extradural electrodes for bowel management. **OM:** Rectum and anal sphincter pressures, quantity of stool passed, bowel evacuation time, and evacuation satisfaction.	**1** Stimulation at S3 increased anal sphincter and rectal pressure **2** Daily use of stimulation significantly improved bowel management with increased frequency of defecation, decreased amount of time required for bowel evacuation, and improved satisfaction.

OM = Outcome measures; CTT = colonic transit times; n/a = information not available; QoL = quality of life

Table 11

Colostomy

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
Randell et al. 2001;[62] New Zealand Downs & Black score=17 Post-test N=52	**Population:** Age range: 22–87; Level of injury: 10 cervical, 16 lumbar/lower thoracic. **Treatment:** 26 subjects with colostomy, 26 subjects without colostomy. **OM:** QoL: systemic symptoms, emotional, social, work and bowel function.	**1** No significant difference between the 2 groups in general well being, emotional, social or work functioning.
Kelly et al. 1999;[59] United Kingdom Downs & Black score=15 Case series N=14	**Population:** Mean age at time of operation: 54.8, range 20–65; Level of injury: C4-T11; 3 cervical, 10 thoracic, 1 lumbar. **Treatment:** Left iliac fossa colostomy (n=12) and right iliac fossa ileostomy (n=2). **OM:** Time spent on bowel care per week; independence in bowel care; QoL.	**1** Colostomy patients: mean time spent on bowel care per week decreased; independence with bowel care increased; quality of life improved in 10 patients **2** Ileostomy patients: no change in mean time spent on bowel care per week.
Munck et al. 2008;[64] Belgium Downs & Black score = 13 Observational N=23	**Population:** Age range at stoma formation: 22–72; Level of injury: cervical to lumbar. **Treatment:** Intestinal stoma formation. **OM:** Bowel care, QoL.	**1** Average time spent on bowel care per week decreased from 5.95 hr to 1.5 hr **2** 3/10 reported cutaneous irritations and 1 reported detachment of the pocket **3** 9/10 had easier bowel care, and 6 had greater independence
Luther et al. 2005;[63] USA Downs & Black score=12 Post-test N=370	**Population:** Case (colostomy): Age range: 20–89; Controls (regular bowel routine): Age range: 20–89; Level of injury: n/a **Treatment:** Colostomy **OM:** Bowel care-related items; QoL.	**1** Mean responses to the QoL items were high but a large number of respondents in both groups expressed dissatisfaction with bowel care. **2** No difference between groups in bowel care outcomes or bowel-related QoL items
Safadi et al 2003;[65] USA Downs & Black Score = 12 Post test N=45	**Population:** Mean age: 55.9; 21 tetraplegic, 24 paraplegic. **Treatment:** right and left colostomy and ileostomy **OM:** QoL, CTT, bowel care time	**1** CTT was significantly longer in the right colostomy. **2** In all surgeries, QoL increased and bowel care time decreased
Branagan et al. 2003;[61] UK Downs & Black score=11 Case Series N=32	**Population:** Mean age at injury: 28.9; Level of injury: 10 cervical, 18 thoracic, 3 lumbar. **Treatment:** Colostomy. **OM:** Bowel care; results of surgery	**1** Time spent on bowel care per week decreased from 10.3 to 1.9 hours. **2** 18 patients experienced greater independence. 25 patients wished they had been offered a stoma earlier. No patients wanted a stoma reversal.
Stone et al. 1990;[58] USA Downs & Black score=11 Case Series N=7	**Population:** Mean age: 51.6; Level of injury C4-T10. **Treatment:** Colostomy **OM:** Bowel care time.	**1** Time spent on bowel care decreased dramatically.
Frisbie et al. 1986;[57] USA Downs & Black score=9 Post-test N=20	**Population:** Median age: 55, range 27–75; Level of injury: 9 cervical, 11 thoracic. **Treatment:** Colostomies or ileostomies. **OM:** Bowel care time, bowel care frequency, bowel care related complaints.	**1** Bowel care frequency increased, bowel care duration lowered. **2** Except for foul odor, bowel care complaints decreased post-operation.
Rosito et al. 2002;[60] USA Downs & Black score=8 Case Series N=27	**Population:** Mean age: 62.9; Level of injury: C4-L3, 17 complete and 10 incomplete injuries. **Intervention:** Colostomy **OM:** QoL questionnaire	**1** QoL significantly improved. **2** Lowered number of hospitalizations by 70.4%.

Author Year; Country Score Research Design Total Sample Size	Methods	Outcome
		3 Time spent on bowel care was reduced.

OM = Outcome measures; QoL = quality of life; n/a = information not available.

Table 12

The Malone Antegrade Continence Enema

Author Year; Country **Score** **Research Design** **Total Sample Size**	**Methods**	**Outcome**
Christensen et al. 2000;[34] Denmark Downs & Black score=17 Retrospective interviews and case series N=29; 19 SCI patients	**Population:** ECC group: Mean age: mean 39.9, range 7–72; Level of injury: T2–T11, conal or cauda equina injuries (n=15). MACE group: Mean age: 32.8, range 15–66; Level of injury: C5-T2 (n=4). **Treatment:** ECC vs. MACE **OM:** colorectal function, practical procedure, impact on daily living and QoL, general satisfaction	**4** The ECC was successful in 53% of participants (8 subjects) **5** The MACE procedure was successful in 75% of participants (3 subjects). **6** Successful treatment with the ECC or the MACE led to significant improvements in QoL.
Teichman et al. 2003;[68] USA Downs & Black score=15 Retrospective review N=6; 3 SCI patients	**Population:** Mean age: 36, range 29–47; Level of injury: T5 complete, C6 complete, C7 incomplete **Treatment:** MACE **OM:** Bowel incontinence; subjective patient satisfaction.	**1** 2 SCI subjects experienced fecal incontinence prior to the operation. Post-operative, both became continent. **2** All SCI subjects were satisfied with their outcomes and rated their QoL higher. **3** All subjects reduced toileting times.
Teichman et al. 1998;[67] USA Downs & Black score=8 Retrospective review N=7; 4 SCI patients	**Population:** Mean age: mean 32.5, range 22–47; Level of injury: C6 complete, C7 incomplete, T5 complete, C6. **Treatment:** MACE **OM:** Number of fecal incontinence episodes per week; Time for evacuation.	**1** 3 SCI subjects experienced fecal incontinence prior to the operation. Post-operative, all became continent. **2** All subjects were able to evacuate within 30 minutes.

OM: Outcome measures; ECC = Enema continence catheter; MACE = Malone antegrade continence enema.