DISEASES OF THE COLON & RECTUM

ORIGINAL CONTRIBUTION

Sacral Nerve Stimulation is more Effective than Optimal Medical Therapy for Severe Fecal Incontinence: A Randomized, Controlled Study

Joe J. Tjandra, M.D., F.R.A.C.S.[a] • Miranda K. Y. Chan, M.B.B.S., F.R.A.C.S. • Chung Hung Yeh, M.D. • Carolyn Murray-Green

Department of Colorectal Surgery, Epworth Hospital, University of Melbourne, Melbourne, Australia

PURPOSE: This randomized study was designed to compare the effect of sacral neuromodulation with optimal medical therapy in patients with severe fecal incontinence.

METHODS: Patients (aged 39–86 years) with severe fecal incontinence were randomized to have sacral nerve stimulation (SNS group; n=60) or best supportive therapy (control; n=60), which consisted of pelvic floor exercises, bulking agent, and dietary manipulation. Full assessment included endoanal ultrasound, anorectal physiology, two-week bowel diary, and fecal incontinence quality of life index. The follow-up duration was 12 months.

RESULTS: The sacral nerve stimulation group was similar to the control group with regard to gender (F:M=11:1 *vs.* 14:1) and age (mean, 63.9 *vs.* 63 years). The incidence of a defect of ≤ 120° of the external anal sphincter and pudendal neuropathy was similar between the groups. Trial screening improved incontinent episodes by more than 50 percent in 54 patients (90 percent). Full-stage sacral nerve stimulation was performed in 53 of these 54 "successful" patients. There were no septic complications. With sacral nerve stimulation, mean incontinent episodes per week decreased from 9.5 to 3.1 ($P<0.0001$) and mean incontinent days per week from 3.3 to 1 ($P<0.0001$). Perfect continence was accomplished in 25 patients (47.2 percent). In the sacral nerve stimulation group, there was a significant ($P<0.0001$) improvement in fecal incontinence quality of life index in all four domains. By contrast, there was no significant improvement in fecal continence and the fecal incontinence quality of life scores in the control group.

CONCLUSIONS: Sacral neuromodulation significantly improved the outcome in patients with severe fecal incontinence compared with the control group undergoing optimal medical therapy.

KEY WORDS: Sacral nerve stimulation; Fecal incontinence.

Fecal incontinence is debilitating and affects approximately 2 percent of the population.[1] The prevalence increases with age, and after aged 50 years, prevalence rates up to 11 percent in men and 26 percent in women have been reported.[2,3] The standard management for symptomatic fecal incontinence includes nonoperative management, such as use of bulking agents, pelvic floor exercises, dietary changes, or by repair of a localized sphincter defect.[4,5] However, the long-term result of a sphincter repair is unpredictable and often poor.[6] Sphincter replacement with artificial bowel sphincter[7] or graciloplasty[8] is used as salvage therapy for end-stage fecal incontinence, but both options are associated with substantial morbidity.

More recently, sacral nerve stimulation has been advocated as a safe and effective therapy for severe fecal incontinence with minimal morbidity.[9–11] Most reports on sacral nerve stimulation comprise a small number of patients from single centers.[12,13] There has been no randomized trial. The efficacy of sacral nerve stimulation in patients with pudendal neuropathy[13] or sphincter defect[14,15] also is controversial.

This is the only randomized trial that has compared sacral nerve stimulation with optimal medical therapy (bulking agents, dietary management, pelvic floor exercises) in patients with significant fecal incontinence by evaluating their respective efficacy and impact on quality of life.

PATIENTS AND METHODS

From March 2004 to March 2006, a prospective, randomized trial of 120 patients with significant fecal incontinence (Wexner's incontinence score > 12) was performed, comparing sacral nerve stimulation (SNS group) with optimal

[a]Deceased.

Read at the meeting of The American Society of Colon and Rectal Surgeons, St. Louis, Missouri, June 2 to 6, 2007.

Address of correspondence: Miranda K. Y. Chan, M.B.B.S., F.R.A.C.S., Department of Colorectal Surgery, Epworth Hospital, University of Melbourne, Melbourne, Australia. E-mail: mirchan@hotmail.com

medical therapy (control group). All patients attended a multidisciplinary pelvic floor clinic. Randomization was performed from the central registry by using sealed envelopes. Optimal medical therapy comprised bulking agents, pelvic floor exercises with a team of dedicated physiotherapists, and dietary management on fluid and fibers with a team of dieticians. The frequency of attendance of control patients with a pelvic floor team varied between patients, depending on needs; generally this was at monthly intervals for the first six months and two-monthly intervals for the second six months. Each pelvic floor exercise session lasted 20 minutes. Biofeedback was provided with digital guidance. Patients were asked to perform identical sets of 50 contractions twice per day at home. Both the SNS and control groups were seen by the primary investigators for formal assessment at baseline, 3 months, 6 months, and 12 months after recruitment. Inclusion criteria for the randomized trial included: involuntary passage of solid or liquid stool at least once per week, refractory to medical therapy and pelvic floor exercises, and aged 35 to 86 years. Exclusion criteria included: rectal prolapse, inflammatory bowel disease, congenital anorectal malformation, neurologic disorders such as Parkinson's disease, multiple sclerosis, spinal-cord injury, stoma *in situ*, pregnancy, external anal sphincter defect of more than 120° of the circumference, bleeding diathesis, and mental or physical disability precluding adherence to study protocol. Defects of the internal anal sphincter alone did not preclude inclusion in the study. Ethics approval was obtained from the institution review board of the participating hospitals, and every patient provided written, informed consent.

Baseline assessment included physical examination, rigid sigmoidoscopy, anorectal manometry, pudendal nerve terminal motor latency (PNTML) measurement,[16] endoanal ultrasound,[5] Wexner's incontinence score,[17] fecal incontinence quality of life index (FIQL),[18] the standard short form-12 (SF-12) health survey questionnaire,[19] and a two-week bowel diary. The FIQL was used to measure four domains (lifestyle, coping/behavior, depression/self-perception, and embarrassment) of quality of life in association with fecal incontinence.[18] The SF-12 is not disease-specific and measures quality of life in the domains of physical health (PH) and mental health (MH); a higher score indicated a better function.[19] Anorectal manometry was performed by using a pull-through technique with an eight-channel water-perfused system previously described.[16] Measurements were made by using the standard nomenclature adopted by the International Working Party.[20] A PNTML longer than 2.6 ms (beyond 2 standard deviations in our laboratory) was defined as having pudendal neuropathy.[21] Incontinent episodes were classified as urge (inability to defer defecation) or passive (no awareness of loss of stool). All patients in the study had both urge and passive fecal incontinence.

Follow-up assessment during subchronic test stimulation and 3, 6, and 12 months after implantation included daily bowel diaries for 2 weeks, fecal incontinence quality of life index (FIQL) of The American Society of Colon and Rectal Surgeons, and the standard short form-12 health survey quality of life questionnaire (SF-12). During the assessment period, antidiarrheal medications were avoided in all patients in the SNS group. In the medical therapy group (control), Imodium® (Janssen-Cilag, Titusville, NJ) was used in 11 patients as a bulking agent to help improve continence; 6 of these patients for less than four months, and the remainder for between four to seven months. For the remaining patients in the control group, antidiarrheal medications were similarly avoided during the study period.

The follow-up duration was for 12 months, and all adverse events were noted. There was complete compliance with follow-up in both groups of patients.

Procedures

All procedures were performed by a single operator (JJT), in a standard fashion, as previously described.[9] General anesthesia was administered without neuromuscular junction nerve blockade. All patients underwent a diagnostic screening phase with peripheral nerve evaluation.[9] Intraoperatively, a 20-gauge, 3.5-inch, insulated foramen electrode was inserted bilaterally into the third sacral foramina (S3) and was then stimulated by using an external pulse generator (Medtronic Interstim™ model 3625, Minneapolis, MN). The optimal foramen which elicits the best motor (*i.e.,* "bellows" contraction of the perineum and contraction of the ipsilateral great toe) with the least voltage was selected for subchronic stimulation. Subchronic stimulation was performed with a percutaneously placed test stimulation lead (Medtronic Interstim™ model 3057) attached to an external pulse generator (Medtronic Interstim™ model 3625).

All patients were tested for a minimum of seven (mean 10.1, SD 2.1) days. Patients who have had a good response during the screening period, as defined by 50 percent or greater reduction in incontinent episodes per week or 50 percent or greater reduction in the number of days with incontinence per week based on the two-week bowel diary, underwent permanent implantation with a quadripolar electrode (Medtronic Interstim™ model 3080) and the pulse generator (Medtronic Interstim™ model 3023), which was placed subcutaneously in the gluteal area.

The pulse generator was activated by telemetry the morning after surgery. The electrode combination that gave the patient the best perception of muscle contraction of the perineum and anal sphincters with the least voltage was chosen for permanent stimulation. Stimulation was cycling (20 seconds on and 8 seconds off) with a pulse width of 210 microseconds, a frequency of 19 pulses per second, and current amplitude adjusted to the patient's perception of muscular contraction.

Statistical Analysis

Data were provided as mean and standard deviation. Statistical analysis was performed by using two-tailed, Wilcoxon's signed-rank test or Mann-Whitney *U* test to compare patient data between groups. Fisher's exact test was used to compare categorical data. $P<0.05$ was considered statistically significant; however, adjustments were made to determine significance level by allowing for multiple comparisons. Thus, statistical significance was reached for Wexner's continence score if $P<0.01$; for SF-12 and anorectal manometry, if $P<0.025$ (0.05/2), and for the four FIQL components, $P<0.0125$ (0.05/4) was significant. Kruskal-Wallis test was used to assess the relationship between the presence of unilateral or bilateral pudendal neuropathy and the improvement in outcome parameters. All statistical analysis was performed with SPSS® software (version 13.0; SPSS Inc., Chicago, IL).

RESULTS

A total of 120 patients were randomized to undergo treatment with sacral nerve stimulation (SNS group) or optimal medical therapy (control group) with bulking agents, pelvic floor exercises, and dietary management. Patients' demographics and characteristics were similar between the two groups (Table 1). Incontinence scores and quality of life parameters (Wexner's incontinence score, FIQL, SF-12) also were comparable between groups (Table 1).

In the control group undergoing optimal medical therapy, there was no significant improvement in fecal continence as assessed by the two-week bowel diary or Wexner's score, FIQL scores and SF-12 quality of life scale. (Table 2) There were no significant changes in the maximum resting and squeeze anal canal pressures.

Of the SNS group, successful cannulation of foramen electrode was achieved in all but one patient who had

Table 1. Patient demographics

	Sacral Nerve Stimulation		*Control group*	*P value (PNE vs. Control group)*
	PNE	*Complete SNS*		
	(n=60)	*(n=53)*	*(n=60)*	
Age (yr)	63.9±13.2	63.4±12.9	63±12.1	NS
Gender (female:male)	11:1	12.3:1	14:1	NS
Prior sphincter repair	31 (52)	29 (55)	35 (58)	NS
Prior anterior resection	3 (5)	3 (6)	3 (5)	NS
Prior anorectal surgery				
Hemorrhoidectomy	11 (18)	10 (19)	13 (22)	NS
Sphincterotomy	3 (5)	3 (6)	5 (8)	NS
Spinal cord injury (lumbar)	1 (1.6)	1 (1.9)	1 (1.6)	NS
External anal sphincter				
Intact	30 (50)	28 (53)	32 (53)	NS
Defect/scar	30 (50)	25 (47)	28 (47)	NS
Anorectal physiology				
Anal pressure (mmHg)				
Resting	30.4±13	29.7±11.7	31.2±11.2	NS
Squeeze	63.5±33.1	61.2±29.1	65.1±31.3	NS
PNTML > 2.6 ms	39 (65)	36 (68)	41 (68)	NS
Unilateral	20 (33)	19 (36)	19 (32)	NS
Bilateral	19 (32)	17 (32)	22 (37)	NS
Wexner's score	16.0±1.3	16.0±1.3	15.2±1.6	<0.05
Bowel diary				
Number of incontinent episodes/week	9.9±12.8	9.5±12.8	9.2±13.4	NS
Days with incontinence/week	3.3±2.4	3.3±2.4	3.3±2.1	NS
Days with staining/week	4±2.3	4±2.3	4.3±1.9	NS
Days with pads per week	3.8±3	3.8±3	3.7±3.4	NS
Fecal incontinence quality of life (FIQL) index				
Lifestyle	2.36±0.97	2.39±0.99	2.26±0.98	NS
Coping / behavior	1.9±0.79	1.89±0.82	1.79±0.82	NS
Depression / self-perception	2.62±0.81	2.65±0.84	2.59±0 .72	NS
Embarrassment	1.92±0.75	1.93±0.78	1.81±0.52	NS
Short form-12 (SF-12) quality of life scale				
Physical health	39.4±11.42	39.81±11.14	39.29±12.12	NS
Mental health	44.3±11.56	45.25±11.09	45.38±12.32	NS

PNE=peripheral nerve evaluation; SNS=sacral nerve stimulation; PNTML=pudendal nerve terminal motor latency; NS = not significant. • Data are means±standard deviations or number of patients with percentages in parentheses.

Table 2. Analysis of bowel diary and Wexner's score in the control group

	Baseline	*3 months**	*12 months**
Wexner's score	15.2±1.6	12.1±2.1	14.1±1.9
Bowel diary			
Number of incontinent episodes/week	9.2±13.4	8.1±14.1	9.4±11.8
Days with incontinence/week	3.3±2.1	2.9±2.4	3.1±1.8
Days with staining/week	4.3±1.9	4.5±2.1	4.5±2.3
Days with pads per week	3.7±3.4	3±3.8	3.2±3.1
Fecal incontinence quality of life (FIQL) index			
Lifestyle	2.26±0.98	2.12±0.91	2.31±0.89
Coping / behavior	1.79±0.82	1.85 ± 0.92	1.86 ± 0.88
Depression / self-perception	2.59±0 .72	2.68 ± 0.65	2.64 ± 0.84
Embarrassment	1.81±0.52	1.7±0.67	1.78±0.61
Short form-12 (SF-12) quality of life scale			
Physical health	39.29±12.12	41.5±9.89	40.5±10.2
Mental health	45.38±12.32	47.82±10.66	48.22±10.12

Data are means±standard deviations. • *The P value for each outcome at 3-month and 12-month compared with baseline was > 0.05.

previous back surgery, requiring the use of bone graft from the sacral area. Of the remaining 59 patients, 54 had 50 percent or greater improvement in continence during subchronic test stimulation; 1 of these 54 patients elected not to proceed to a permanent implant because of concerns that she might require magnetic resonance imaging of her brain after excision of a meningioma eight years previously. In total, 53 patients in the SNS group underwent a permanent sacral nerve implant, positioned through the third sacral nerve foramina. Initial mean amplitude of stimulation of the permanent sacral nerve implant was 1.27 V (SD, 0.82). During 12-month follow-up, the program needed readjustment for a mean of 3 occasions (SD, 0.25) in all patients, largely to maintain efficacy and patient perception of stimulation. Adjustment of the program has included combinations of changes in the electrode used for stimulation, amplitude and rate. At 12-month follow-up, mean amplitude was 2.12 V (SD, 1.28).

Fecal continence was greatly improved with chronic sacral nerve stimulation immediately after implantation and was sustained during the follow-up period. Incontinent episodes per week improved from a mean of 9.5 (SD, 12.8) at baseline to 4.2 (SD, 12.3; $P<0.0001$) at 6 months and to 3.1 (SD, 10.1; $P<0.0001$) at 12 months. Both urge and passive incontinence improved substantially. Table 3 and Figure 1 show that there was a significant decrease in the number of incontinent episodes per week, the number of incontinent days per week, fecal staining, and use of pads. Ability to defer defecation also improved significantly (Fig. 2A). However, ability to completely empty the bowel was not affected (Fig. 2B).

Table 3. Analysis of Wexner's score, anorectal manometry, and bowel diary in the SNS group

	Baseline	*Screening with PNE*	*3 months*	*6 months*	*12 months*
Wexner's score*	16±1.3	1.2±0.9	1.1±1	Not reported	1.2±1.8
Anorectal Manometry					
Resting pressure†	29.7±11.7	32±11.2	32.8±16.9	30±16.9	30.1±16.1
Squeeze pressure†	61.2±29.1	50.2±15.9	63.4±32.6	66.1±39	66.3±40.4
Bowel diary					
Incontinent episodes/week*	9.5±12.8	0.7±1.6	2.9±6.3	4.2±12.3	3.1±10.1
Days with incontinence/week*	3.3±2.4	0.3±0.5	1±1.7	1.1±1.8	1±1.7
Days with staining/week*	4±2.3	0.6±1.1	1.3±1.7	1.6±2.1	1.4±2
Days using pads/week*	3.8±3	1.1±2.2	1.6±2.6	1.6±2.6	2.2±3
Fecal incontinence quality of life (FIQL) index					
Lifestyle‡	2.39±0.99	2.79±0.95¦	3.34±0.72	3.24±0.79	3.31±0.72
Coping / behavior‡	1.89 ± 0.82	2.33±0.97¶	2.87±0.8	2.71±0.82	2.68±0.87
Depression / self perception‡	2.65±0.84	2.94±0.88#	3.31±0.77	3.31±0.79	3.25±0.8
Embarrassment‡	1.93±0.78	2.36±1**	2.89±0.85	2.83±0.87	2.76±0.94
Short form-12 (SF-12) Quality of life scale					
Physical health§	39.81±11.14	41.66±9.13	43.18±11.68	42.49±11.16	42.22±9.25
Mental health§	45.25±11.09	47.32±10.45	50.16±10.41	49.22±10.13	49.22±10.88

SNS=sacral nerve stimulation; PNE=peripheral nerve evaluation. • Data are means±standard deviations. • *P<0.0001 when comparing outcomes at all time-points with baseline. • †P>0.05 when comparing outcomes at all time-points with baseline. • ‡P<0.0001 when comparing outcomes at 3-months, 6-months, and 12-months with baseline. • §P>0.025 at all time-points except for mental health at three-months (P=0.005) and six-months (P=0.005). • ¦P=0.014; ¶P=0.002; #P=0.031; **P=0.016.

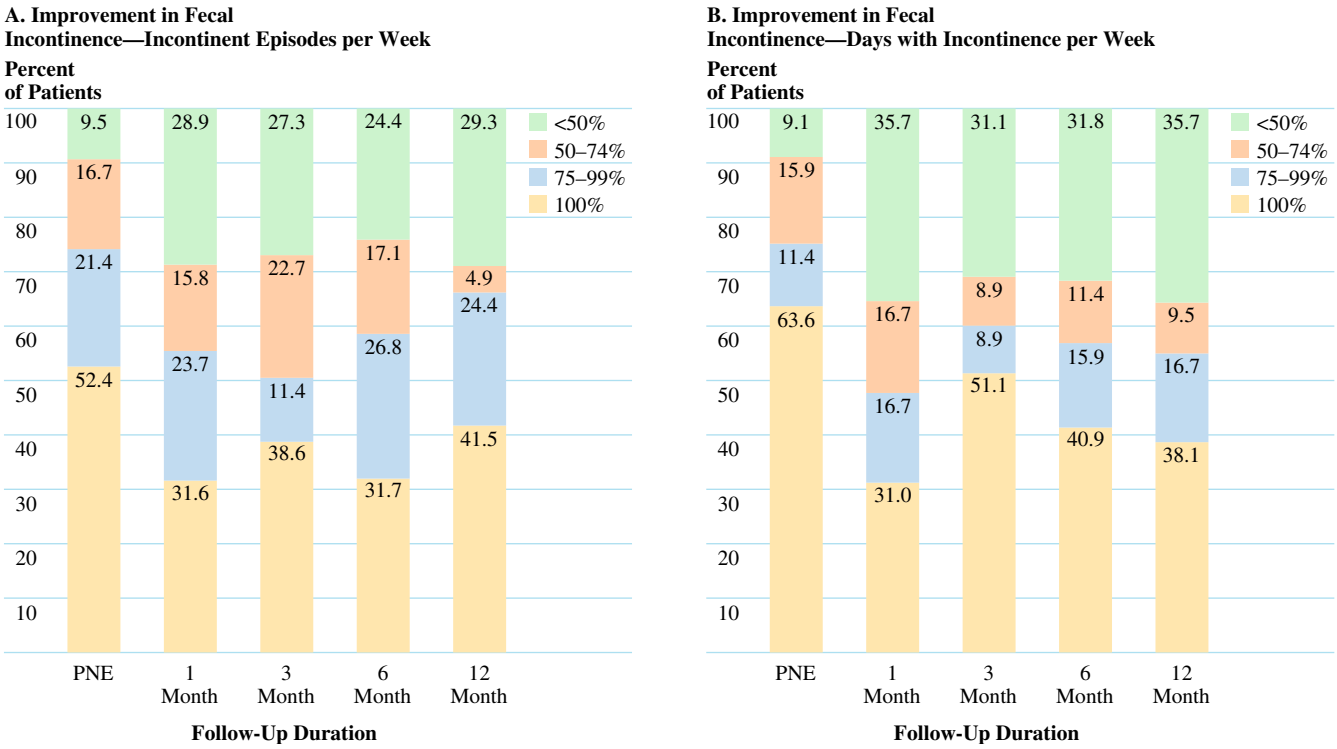
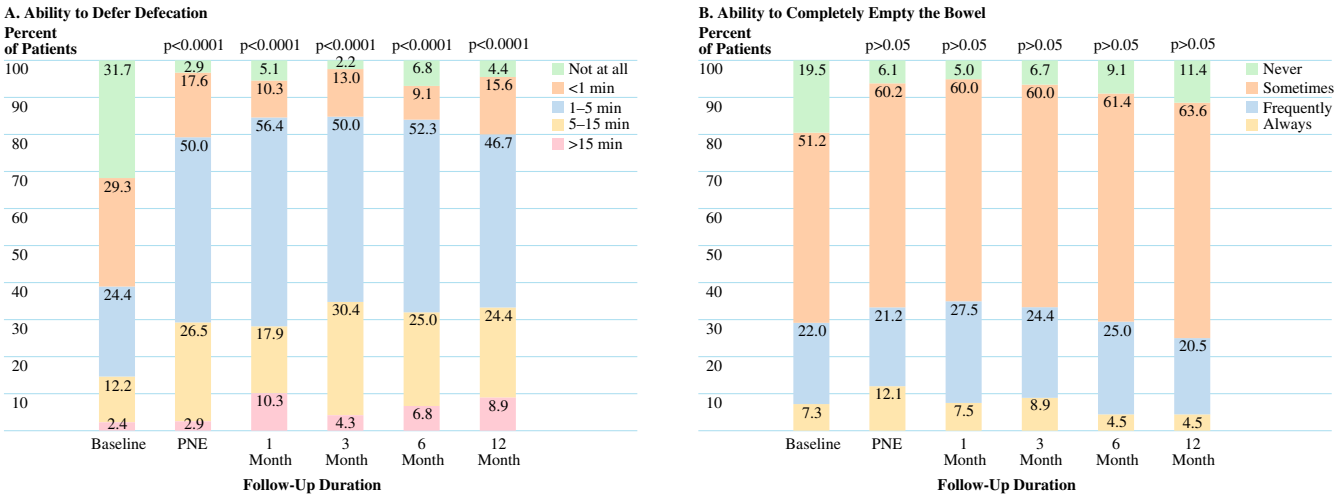


FIGURE 1. Improvement in fecal incontinent episodes per week (A) and in days with fecal incontinence per week (B) during sacral nerve stimulation. PNE = peripheral nerve evaluation.

Perfect continence was accomplished in 25 patients (47.2 percent). Twenty-two patients (41.5 percent) and 13 patients (24.4 percent) had 100 percent and 75 to 99 percent improvement, respectively, in incontinent episodes per week. None of the patients have had worsening of fecal continence as a result of sacral nerve stimulation. All three patients who have had ultralow (n=2) or low (n=1) anterior resection of rectum have had significant improvement, with improvement in incontinent episodes per week of 100 percent (n=1), 75 to 99 percent (n=1), and 50 to 74 percent, respectively. A single patient with lumbar spinal injury also has a significant improvement of 50 to 74 percent in both the incontinent episodes and incontinent days per week with sacral nerve stimulation.

FIGURE 2. Ability to defer defecation (A) and to completely empty the bowel (B) during sacral nerve stimulation. PNE = peripheral nerve evaluation.



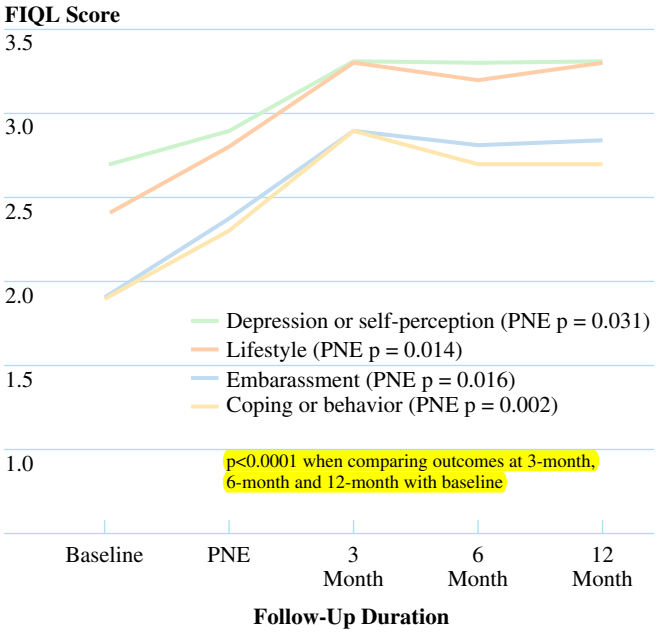
There was a significant improvement in all four scales of FIQL, evident immediately after implantation (Table 3; Fig. 3). There was no significant improvement in both the physical and mental health scale of SF-12 throughout the follow-up period, except in the mental health scale at three months (P=0.005) and six months (P=0.005) after full-stage sacral nerve implant (Fig. 4).

Neither the maximum resting nor squeeze anal canal pressures changed significantly during the screening trial with peripheral nerve evaluation at 3, 6, and 12 months of chronic sacral nerve stimulation. Baseline pudendal nerve terminal motor latency has no association with the improvement, at 12-month follow-up, in incontinent episodes per week (P=0.66) or incontinent days per week (P=0.59) related to sacral nerve stimulation.

Adverse events with SNS included pain at implant site especially in slimmer patients (6 percent), seroma (2 percent), which resolved after percutaneous aspiration, and excessive tingling in the vaginal region (9 percent). There was no septic complication requiring explantation. There was no adverse event associated with urinary or sexual function. In the control group, six patients complained of constipation as the result of treatment with Imodium®.

The SNS group has significantly better functional outcome than the control group in terms of fecal continence and FIQL scores throughout the entire study (Table 4).

FIGURE 3. Fecal incontinence quality of life assessment (FIQL score) in the sacral nerve stimulation group. SNS = sacral nerve stimulation; FIQL = Fecal incontinence quality of life scale; PNE = peripheral nerve evaluation.



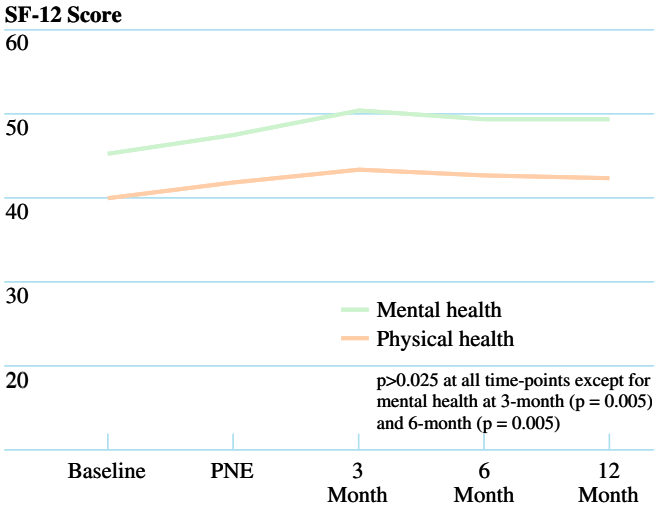


FIGURE 4. SF-12 quality of life assessment in the sacral nerve stimulation group. SNS = sacral nerve stimulation; SF-12 = short form-12 health survey; PNE = peripheral nerve evaluation.

DISCUSSION

This study has shown clearly that at 12-month follow-up sacral nerve stimulation is much more effective than supervised optimal medical therapy that comprises bulking agents, pelvic floor exercises, and dietary management. The presence of a control group has helped to reject the concept of a placebo effect of sacral nerve stimulation-an observation that has been suggested in a previous cross-over study.[22] More than half the patients have had a previous sphincter repair and approximately two-thirds of patients had evidence of pudendal neuropathy. Close to half the patients in the SNS group had evidence of a defect (120° or less) of external anal sphincter. Despite presence of such a significant pathophysiology, the results of sacral nerve stimulation have been impressive, with 41.5 percent and 24.4 percent of patients, respectively, having had 100 percent and 75 to 99 percent improvement in incontinent episodes per week. In addition, perfect continence was achieved in 47.2 percent of patients. In particular, none of the patients has deterioration of fecal continence after chronic sacral nerve stimulation. Sacral nerve stimulation seems to be effective in treating fecal incontinence associated with a wide range of contributing factors (Table 1). The efficacy of SNS in treating fecal incontinence following a low or ultralow anterior resection in this study might provide an expanded indication for its use.

In addition to a sustained functional improvement, quality of life was significantly enhanced as measured by fecal incontinence quality of life (FIQL) scores; this is to

Table 4. Comparison of outcomes between the SNS and the control group

	3-month			*12-month*		
	SNS group	*Control group*	*P value*	*SNS group*	*Control group*	*P value*
Wexner's score	1.1±1	12.1±2.1	0.0001	1.2±1.8	14.1±1.9	0.0001
Bowel diary						
Incontinent episodes/week	2.9±6.3	8.1±14.1	0.0149	3.1±10.1	9.4±11.8	0.0031
Days with incontinence/week	1±1.7	2.9±2.4	0.0001	1±1.7	3.1±1.8	0.0001
Days with staining/week	1.3±1.7	4.5±2.1	0.0001	1.4±2	4.5±2.3	0.0001
Days using pads/week	1.6±2.6	3±3.8	0.0261	2.2±3	3.2±3.1	0.0851
Fecal incontinence quality of life (FIQL) index						
Lifestyle	3.34±0.72	2.12±0.91	0.0001	3.31±0.72	2.31±0.89	0.0001
Coping/behavior	2.87±0.8	1.85±0.92	0.0001	2.68±0.87	1.86±0.88	0.0001
Depression / self perception	3.31±0.77	2.68±0.65	0.0001	3.25±0.8	2.64±0.84	0.0001
Embarrassment	2.89±0.85	1.7±0.67	0.0001	2.76±0.94	1.78±0.61	0.0001
Short form-12 (SF-12) quality of life scale						
Physical health	43.18±11.68	41.5±9.89	0.4095	42.22±9.25	40.5±10.2	0.3522
Mental health	50.16±10.41	47.82±10.66	0.2416	49.22±10.88	48.22±10.12	0.6138

SNS=sacral nerve stimulation. • Data are means ± standard deviations unless otherwise indicated.

be expected because fecal incontinence is socially disabling.[23] Changes in SF-12 quality of life scores in both the physical and mental life scales were not as significant as FIQL in this study. This is somewhat surprising; however, SF-12 is an assessment for general well-being and is affected by many factors that might interfere with the benefits from an improved fecal continence. A similar observation was noted in another study on injectable silicone biomaterial from our center.[24]

Screening trial with peripheral nerve evaluation is the single most important predictive test for response to SNS; all patients in this study who have had a good response to the screening trial had a good and sustained response to permanent implant. Thus, screening trial with peripheral nerve evaluation is essential in selecting appropriate patients for SNS. Migration of the temporary test stimulation lead during screening trial has not been a problem in this study, largely because of the secure manners the electrode was taped in place. Compared with permanent quadripolar lead, test stimulation lead is relatively inexpensive, fully reversible, and easy to remove in the office without the need for any anesthesia, which is required for removal of a quadripolar lead. In addition, temporary test stimulation lead also provides the flexibility, in selected cases, insertion of a lead on each side (right and left S3) to ascertain the side with the best clinical response; this would have been impractical with the much more expensive quadripolar lead.

In this study, 29.3 percent of SNS patients have an improvement in incontinent episodes per week of less than 50 percent. A recent study has similarly shown that there is an unexplained secondary loss of therapeutic effect in approximately one-third of patients, especially of nonneurologic fecal incontinence, treated by permanent sacral nerve stimulation.[13] There is no other clear predictor of success for chronic sacral nerve stimulation. The presence of pudendal neuropathy did not have an impact on the outcome of SNS in our study, although this is an area of controversy because some authors[9] believe that an intact pudendal nerve function and a normal nerve-muscle connection are essential for a good outcome with sacral nerve stimulation . Increasingly it is accepted that pudendal nerve terminal motor latency has a limited predictive value.[9,10] A recent report has suggested that fecal incontinence of neurologic origins is more likely to have a good outcome from SNS.[13] We have included patients with moderate defect of external anal sphincter, up to 120° of the circumference. A recent report has supported this observation in noting that patients with a sphincter defect of less than 33 percent of the circumference had equivalent results as those having intact sphincters.[25]

The average patient needs adjustment of the sacral nerve program on three occasions in the first 12 months. This is likely that inward migration or changes of the position of the electrode to the sacral nerve (S3) occurs in the early postoperative period. With time, adhesions and fibrosis are likely to stabilize the position of the electrode. Thus, it is important that patients are regularly followed-up after implantation of SNS, and physicians ought to be familiar with sacral nerve programming.

The efficacy of SNS is unlikely to mediate significantly through the sphincter mechanism, because there was no significant increase in both the maximum resting and squeeze anal canal pressures in this or other studies.[9,26,27] Some investigators, however, have shown increases in resting and/or squeeze anal canal pressures,[15,28,29] and there was a general belief that the improved continence in SNS was attributed to a direct stimulation on the external anal sphincter.[9] Other hypotheses on the mechanism of action of SNS have included effect on autonomic nervous system,[15,28] modulation of anorectal reflexes,[12] modulation of corticospinal pathway,[30] and changes in rectal sensitivity and

motility.[16,31,32] The precise mechanism of action of sacral nerve stimulation remains speculative at this stage.

The procedure seems to be safe, with minimal complications. In particular, with meticulous aseptic techniques there were no septic complications. This could be partly attributed to the fact that none of the patients had a permanent quadripolar lead (Medtronic Interstim™ model 3080) during the screening phase. The use of a permanent quadripolar lead for screening trial might be associated with a higher septic complication.[9,33] When choosing an appropriate therapy for patients with end-stage fecal incontinence, the safety profile of SNS compared with the higher complication rates of other alternative procedures, such as dynamic graciloplasty or artificial bowel sphincter, should be taken into account. [6]

Our study is somewhat limited because the follow-up was only for 12 months. However, some of our control patients who underwent optimal medical therapy have found it difficult to continue with their disability and have sought therapy with SNS after the 12-month study. Longer follow-up of all our SNS patients is in progress and shall be separately reported. The lack of a dramatic response with medical therapy was surprising, but this could relate to inclusion of patients with more severe fecal incontinence with a high proportion of patients having pudendal neuropathy. For example, in a recent study on biofeedback therapy, only patients with mild-to-moderate fecal incontinence were included.[34]

The safety profile, efficacy, and simplicity of sacral nerve stimulation, even in patients with a limited defect of external sphincter and pudendal neuropathy, would raise consideration of using this therapy as the first-line or second-line surgical therapy, rather than limiting its use for end-stage fecal incontinence. Currently there is an ongoing, randomized trial in our center that compares sacral nerve stimulation with a sphincter repair. Clearly the cost of the device is a concern, but a recent outcome and cost analysis of SNS for fecal incontinence has shown that it is highly cost effective.[35]

REFERENCES

1. Nelson R, Norton N, Cautley F, Furner S. Community based prevalence of anal incontinence. JAMA 1995; 274:559–61.
2. Campbell AJ, Reinken J, McCosh L. Incontinence in the elderly: prevalence and prognosis. Age Ageing 1985;14:65–70.
3. Roberts RO, Jacobsen SJ, Reilly WT, Pemberton JH, Lieber MM, Talley NJ. Prevalence of combined fecal and urinary incontinence: a community-based study. J Am Geriatr Soc 1999;47:837–41.
4. Madoff RD, Williams JG, Caushaj PF. Fecal incontinence. N Engl J Med 1992;326:1002–7.
5. Tjandra JJ, Milsom JW, Schroeder T, Fazio V. Endoluminal ultrasound is preferable to electromyography in mapping anal sphincter defect. Dis Colon Rectum 1993;36:689–92.
6. Tan JJ, Chan MK, Tjandra JJ. Evolving therapy for fecal incontinence. Dis Colon Rectum 2007;50:1950–67.
7. Wong WD, Congliosi SM, Spencer MP, *et al.* The safety and efficacy of the artificial bowel sphincter for fecal incontinence: results from a multicenter cohort study. Dis Colon Rectum 2002;45:1139–53.
8. Wexner SD, Baeten C, Bailey R, *et al.* Safety and efficacy of dynamic graciloplasty for fecal incontinence: report of a prospective, multicenter trial. Dis Colon Rectum 2000;43: 743–51.
9. Tjandra JJ, Lim JF, Matzel K. Sacral nerve stimulation - an emerging treatment for faecal incontinence. ANZ J Surg 2004;74:1098–106.
10. Matzel KE, Kamm MA, Stosser M, *et al.* Sacral spinal nerve stimulation for faecal incontinence: multicentre study. Lancet 2004;363:1270–6.
11. Hetzer FH, Hahnloser D, Clavien P-A, Demartines N. Quality of life and morbidity after permanent sacral nerve stimulation for fecal incontinence. Arch Surg 2007;142:8–13.
12. Kenefick NJ, Nicholls RJ, Cohen RG, Kamm MA. Medium-term results of permanent sacral nerve stimulation for faecal incontinence. Br J Surg 2002;89:896–901.
13. Gourcerol G, Gallas S, Michot F, Denis P, Leroi AM. Sacral nerve stimulation in fecal incontinence: are there factors associated with success. Dis Colon Rectum 2007;50:3–12.
14. Conaghan P, Farouk R. Sacral nerve stimulation can be successful in patients with ultrasound evidence of external anal sphincter disruption. Dis Colon Rectum 2005;48: 1610–4.
15. Rosen HR, Urbarz C, Holzer B, Novi G, Schiessel R. Sacral nerve stimulation as a treatment for fecal incontinence. Gastroenterology 2001;121:536–41.
16. Tjandra JJ, Sharma BR, McKirdy H, Lowndes RH, Mansel RE. Anorectal physiological testing in defaecatory disorders: a prospective study. ANZ J Surg 1994;64:322–6.
17. Jorge JM, Wexner SD. Etiology and management of fecal incontinence. Dis Colon Rectum 1993;36:77–97.
18. Rockwood TH, Church JM, Fleshman JW *et al.* Fecal incontinence quality of life scale: quality of life instrument for patients with fecal incontinence. Dis Colon Rectum 2000;43:9–16.
19. Ware JE, Kosinski M, Keller SD. SF-12: How to score the SF-12 Physical and Mental Health Summary Scales. Boston: The Health Institute, New England Medical Center, 1995.
20. Lowry AC, Simmang CL, Boulous P, *et al.* Consensus statement of definitions for anorectal physiology and rectal cancer. Colorectal Dis 2001;3:272–5.
21. Ooi BS, Tjandra JJ, Tang CL, Dwyer P, Carey M. Anorectal physiological testing before and after a successful sphincter repair: a prospective study. Colorectal Dis 2000;2:220–8.
22. Leroi AM, Parc Y, Lehur PA, *et al.* Efficacy of sacral nerve stimulation for fecal incontinence. Results of a multicenter double-blind crossover study. Ann Surg 2005;242:662–9.
23. Rothbarth J, Bemelman WA, Meijerink WJ. What is the impact of fecal incontinence on quality of life? Dis Colon Rectum 2001;44:67–71.
24. Tjandra JJ, Lim JF, Hiscock R, Rajendra P. Injectable silicone biomaterial for fecal incontinence caused by internal anal sphincter dysfunction is effective. Dis Colon Rectum 2004;47:2138–46.

25. Melenhorst J, Koch SM, Uludag O, van Gemert WG, Baeten CG. Sacral nerve modulation for faecal incontinence: repaired anal sphincter complex versus anal sphincter defect. Colorectal Dis 2006;8(4):1–2.
26. Altomare D, Rinaldi M, Petrolino M, *et al*. Permanent sacral nerve modulation for faecal incontinence and associated urinary disturbances. Int J Colorectal Dis 2004;19:203–20.
27. Leroi AM, Michot F, Grise P, Denis P. Effect of sacral nerve stimulation in patients with faecal and urinary incontinence. Dis Colon Rectum 2001;44:779–89.
28. Ganio E, Masin A, Ratto C, *et al*. Short-term sacral nerve stimulation for functional anorectal and urinary disturbances: results in 40 patients: evaluation of a new option for anorectal functional disorders. Dis Colon Rectum 2001;44:1261–7.
29. Matzel K, Bittorf B, Stadelmaier U, Hohenfellner M, Hohenberger W. Sakralnervstimulation in der Behandlung der Stuhlinkontinenz. Chirurg 2003;74:26–32.
30. Schurch B, Reilly I, Reitz A, Curt A. Electrophysiological recordings during the peripheral nerve evaluation (PNE) test in complete spinal cord injury patients. World J Urol 2003;20:319–22.
31. Matzel KE, Stadelmaier U, Gall FP. Direct electrostimulation of the sacral spinal nerves in diagnosis of anorectal function. Lang Arch Chirurgie 1995;380:184–8.
32. Matzel KE, Stadelmaier U, Hohenfellneer M, Gall FP. Electrical stimulation for the treatment of fecal incontinence. Lancet 1995;346:1124–7.
33. HiJaz A, Vasavada SP, Daneshgari F, Frinjari H, Goldman H, Rackley R. Complications and troubleshooting of two-stage sacral neuromodulation therapy: a single-institution experience. Urology 2006;68:533–7.
34. Byrne CM, Solomon MJ, Young JM, Rex J, Merlino CL. Biofeedback for fecal incontinence: short-term outcomes of 513 consecutive patients and predictors of successful treatment. Dis Colon Rectum 2007;50:417–27.
35. Hetzer FH, Bieler A, Hahnloser D, Lohlein F, Clavien P-A, Demartines N. Outcome and cost analysis of sacral nerve stimulation for faecal incontinence. Br J Surg 2006;93:1411–7.