



Universiteit  
Leiden  
The Netherlands

## Neuromodulation and urodynamics in lower urinary tract symptoms

Groenendijk, P.M.

### Citation

Groenendijk, P. M. (2008, December 9). *Neuromodulation and urodynamics in lower urinary tract symptoms*. Retrieved from <https://hdl.handle.net/1887/13341>

Version: Corrected Publisher's Version

License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

Downloaded from: <https://hdl.handle.net/1887/13341>

**Note:** To cite this publication please use the final published version (if applicable).



## Chapter 2

# **Five-year follow-up after Sacral Neuromodulation (SNM): single center experience**

P.M. Groenendijk, A.A.B. Lycklama à Nijeholt, T.J. Ouwerkerk and U. van den Hombergh  
Neuromodulation 2007; 10(4): 293-298

## Abstract

---

**Objective:** We studied long term clinical efficacy of sacral neuromodulation (SNM) therapy in patients with refractory urgency incontinence (UI), urgency/frequency (UF) and voiding difficulty (VD), together with urodynamic data at baseline and six months post implant.

**Materials and Methods:** Twenty-two patients were implanted with a neurostimulator after a positive response to a Percutaneous Nerve Evaluation test defined as a greater than 50% improvement in symptoms.

**Results:** At five-year follow-up, for 10 out of 15 UI patients the number of incontinent episodes and pad usage per day decreased significantly. Two of five UF patients were successfully treated with SNM with the number of daily voids for all UF patients decreasing from 25 to 19 and average voided volume increased from 98 to 212 ml. One of the two VD patients was able to void to completion. Mean first sensation of filling (FSF) at the six months urodynamic investigation for the UI and UF patients increased from 78 to 241 ml and 141 to 232 ml respectively, and the maximum bladder capacity increased from 292 to 352 ml and 223 to 318 ml respectively. Five of 22 patients underwent device explant and one patient still has an inactive stimulator implanted.

**Conclusion:** SNM is an effective treatment modality that offers sustained clinical benefit in the majority of patients with refractory urgency incontinence, urgency/frequency and voiding difficulty that do not respond to other, more conservative therapies.

## Introduction

---

For voiding disorders characterized by symptoms of urgency incontinence, urgency/frequency and voiding difficulty, a wide variety of initial treatment modalities are available including behavioural techniques such as pelvic floor muscle exercises and biofeedback, pharmacotherapeutic options that include anticholinergic and antispasmodic agents, and for complete and incomplete retention, clean intermittent (self) catheterization. However, many of these disorders cannot be treated successfully with these conservative treatment modalities [1,2] leaving various types of invasive surgeries as “last resort” options. For patients with refractory voiding complaints who do not respond favorably to conservative therapies, sacral neuromodulation therapies may be a valuable option before more invasive and irreversible surgical approaches are applied.

Sacral Neuromodulation (SNM) is widely accepted as a novel treatment modality for a variety of different voiding disorders. In 1988 Tanagho and Schmidt first reported on this therapy [3]. Since then, more than 30.000 patients worldwide have received permanent neurostimulators. Cure rates from 60 to 100% have been reported in the literature for patients with refractory voiding dysfunctions that include urgency incontinence (UI), urgency/frequency (UF) and voiding difficulty (VD) due to chronic non-obstructive retention [4-7]. Although the exact mechanism/mechanisms of action for SNM is still not fully understood, two hypotheses have been reported. Neuromodulation may enhance urethral and pelvic floor tone, inhibiting detrusor overactivity thus restoring normal bladder function [8-11], or it may affect bladder function via afferent nerve fibers [12].

At the Leiden University Medical Center, Leiden, The Netherlands, patients with symptoms of urgency incontinence, urgency/frequency and voiding difficulty (incomplete and complete retention) were enrolled in a prospective randomized study evaluating the clinical efficacy and safety of SNM. Urodynamic evaluation was a secondary study end point that was performed at baseline and six-months post implant and not used to define success but to monitor possible changes in bladder and urethral behaviour during stimulation. This present study was part of a large multicenter trial (Medtronic MDT-103) and we now report on the long-term efficacy and safety results of patients included in our hospital together with the urodynamic changes at six months post implant.

## Materials and Methods

---

Patients with voiding dysfunction symptoms refractory to standard physical and medical therapy were included in a large multicenter trial (Medtronic MDT-103). Baseline screening included physical examination, detailed medical history, completion of a voiding diary, urodynamic testing and quality of life questionnaires (SF-36 and BDI). A Percutaneous Nerve Evaluation (PNE) test with a temporary lead (model 041830 Medtronic Inc., Minneapolis, USA) was performed after obtaining written informed consent. A permanent neurostimulator model 3023 (Medtronic Inc., Minneapolis, USA) was implanted in patients responding with an improvement of more than 50% in their main symptoms during the PNE test. The technique used in all patients was an open transforaminal surgical technique with non-tined leads, Medtronic #3080 (Medtronic Inc, Minneapolis, Minnesota, USA) with a fixed anchor, anchored to the periosteum. The 3080 lead has 4 equal length electrodes, equally spaced. All implants were performed unilaterally after completion of a positive PNE (i.e., no staged approach). Unipolar stimulation was used where the implanted neuropulse generator was positive and one of the four electrodes was negative. Parameters were evaluated every six months during regular follow-up and were changed only in case of lack of efficacy or adverse events.

Urodynamic evaluation was performed at baseline and at six months after implant and included simple uroflowmetry with residual determination and filling cystometry with a detrusor pressure/flow study. Patients completed a voiding diary at baseline, during and after the PNE test, at one, three, and six months follow-up and thereafter at every other half-year follow-up visit after implantation to document voiding habits and symptoms. In addition, patients rated the severity of their leaking episodes on a scale of 0 to 3 (0=dry, 1=mild, 2= moderate and 3=heavy). In our hospital, filling cystometry was performed with the MMS UD 2000 (Medical Measurement Systems, Enschede, the Netherlands) and a Gaeltec CTU/2E/L-4 12F (Gaeltec Ltd, Dunvegan, Isle of Skye, Scotland) microtip catheter.

### *Statistics*

Comparison of test results was completed using a two-sample Student's t-test. Results in the figures are presented as mean  $\pm$  standard deviation. Statistical results were adjusted according to the equality of variances and for multiple comparisons of the data.

## Results

---

Twenty-two patients, 21 females and 1 male, were implanted with a permanent neurostimulator after responding successfully (>50% improvement in main symptoms) to the PNE. Seventeen patients (77%) succeeded on the first PNE, three patients underwent two test evaluations, while the remaining two underwent three test evaluations before becoming a candidate for permanent implantation. Reason for this was test lead displacement or some but unsatisfactory results. Fifteen patients suffered from refractory urgency incontinence (UI), five from urgency/frequency

(UF) and two from voiding difficulty (VD) due to chronic, non-obstructive urinary retention requiring intermittent self-catheterization. Mean age at study enrolment was 45.7 years (range 31-58) and mean duration of symptoms was 8.5 years. No significant changes were seen in quality of life in all patients post implant.

*Urgency incontinence (UI)*

Twelve out of 15 patients implanted for UI reached their five-year follow-up, one patient was considered a late failure and two were explanted after 17 and 20 months. One of these explanted patients died nine months after the explantation due to a non-treatment related cause. One out of three failure patients with UI had progressive fecal incontinence due to an unknown neurological cause and another had a severe progressive psychiatric disorder. These three failure patients were included in the analysis. Based on voiding diary data, UI patients showed statistically significant improvement in their symptom reduction. At five-year follow-up, the number of incontinence episodes per 24 hours decreased from 11.6 to 3.7 (p=0.002) and the number of pads used per day from 6.9 to 2.5 (p=0.004). The severity of leaking episodes decreased from an average of 2.2 at baseline to 1.9. At five-year follow-up, 10 out of 12 patients (83%) had more than 50% improvement in symptoms, including two patients who were completely dry.

Urodynamic data, available for 11 UI patients at six months post implant, showed an increase of mean first sensation of filling from 78 to 241 ml (p=0.0008) corresponding with 30% and 72% of bladder capacity respectively (Table 1). No significant changes were observed in simple uroflowmetry data (Table 2).

**Table 1.** Water Cystometry: Baseline through 6 months, all implanted Urgency Incontinence patients

Urodynamic Test Variable				p-value*
	n	Avg. at Baseline	Avg. at six months	
First Sensation of Fullness (FSF) Bladder Volume (ml)	11	78.0 ± 77.4	240.6 ± 162.9	0.0008
Maximum Bladder Volume prior to void (ml)	11	292.4 ± 105.8	352.8 ± 180.5	0.13
Detrusor pressure prior to void (cm H <sub>2</sub> O)	11	30.0 ± 15.1	21.5 ± 12.1	0.18
Bladder Volume at FSF (% of bladder capacity)	11	30.0 ± 30.2	71.8 ± 29.0	0.0017

\*Statistical Comparison: paired t-test

**Table 2.** Simple Uroflowmetry: Baseline versus 6 months for 7 patients with Urgency Incontinence and 2 with Urgency/Frequency symptoms

Urgency Incontinence				Urgency/Frequency		
	n	Avg. at Baseline	Avg. at six months	n	Avg. at Baseline	Avg. at six months
Peak flow rate (ml/sec)	7	16.93 ± 6.34	16.16 ± 9.78	2	17.50 ± 7.78	15.00 ± 2.83
Mean flow rate (ml/sec)	7	7.20 ± 4.44	5.74 ± 2.52	2	7.50 ± 4.95	5.50 ± 0.71
Total voided volume (ml)	7	211.43 ± 89.79	192.57 ± 106.54	2	133.00 ± 18.38	276.00 ± 90.51
Flow time (sec)	7	6.57 ± 6.53	8.57 ± 4.76	2	6.00 ± 1.41	8.00 ± 2.83

*Urgency/frequency*

Three out of 5 patients with UF attended a five-year follow-up visit and two were explanted (one male patient and one patient with a positive response but postoperative complaints of “swollen abdomen”). The treatment was unsuccessful in one patient (who also had progressive fecal incontinence of unknown etiology, which resulted in urinary and fecal diversion). SNM was successful in two patients (67%) at five-year follow-up as measured by average voided volume per void. According to the voiding diary data, the average voided volume per void increased from 98 ml to 212 ml and the number of voids per 24 hours decreased from 24 to 11.

In all five patients, at the six months urodynamic evaluation, the mean first sensation of filling increased from 141 ml to 232 ml (p=0.18) and maximum bladder capacity increased from 223 ml to 318 ml (Table 3). Simple uroflowmetry did not show significant changes at six months follow-up (Table 2). Due to the small sample size the results of SNM treatment were not statistically significant, even though clear clinical benefit could be demonstrated in two out of the five patients.



**Table 3.** Water Cystometry: Baseline through 6 months, all implanted Urgency Incontinence patients

Urodynamic Test Variable				p-value*
	n	Avg. at Baseline	Avg. at six months	
First Sensation of Fullness (FSF) Bladder Volume (ml)	5	142.2 ± 40.8	231.8 ± 148.0	0.18
Maximum Bladder Volume prior to void (ml)	5	223.0 ± 64.5	318.2 ± 121.0	0.11
Detrusor pressure prior to void (cm H <sub>2</sub> O)	5	15.2 ± 8.9	13.2 ± 8.64	0.70
Bladder Volume at FSF (% of bladder capacity)	5	66.3 ± 20.9	68.3 ± 37.6	0.87

\*Statistical Comparison: paired t-test

#### *Voiding difficulty*

Five-year follow-up was available for the two voiding difficulty patients. One patient was able to void to completion without catheterization, while the other had less than 50% improvement in reduction of the residual volume.

#### *Adverse events/Failures*

Since study enrolment, five out of 22 implanted patients (two UI, two UF and one VD) underwent device explantation. The mean time to device explant was 20 months (range 15-26). Reasons for device explant were lack of efficacy in two patients and pain at the neuropulse generator site in two patients. The fifth patient who complained of a "swollen abdomen" during stimulation which failed to respond to conservative therapies was advised to undergo explantation of the device despite a good response to SNM treatment. One patient, considered a treatment failure, still has the inactive neurostimulator in place. Data from all of these patients was included in the analysis of efficacy. All failure patients (except for the patient with the complaint of "swollen abdomen") underwent revision operations that consisted mainly of repositioning of the electrode. Dislodgement of the electrode array, rendering it refractory to reprogramming, was found in one case of lack of efficacy. Electrode repositioning/replacement was required to regain clinical benefit once again. During the five-year follow-up, five of the 13 successfully treated patients underwent electrode repositioning because of diminishing results.

## Discussion

---

The present study expands the already available evidence on the long-term efficacy and safety of SNM for the treatment of refractory UI, urgency/frequency syndromes and non-obstructive urinary retention [12,13]. Clinical efficacy has been reported to be as high as 100% in different studies, depending on patient selection, symptom severity and the reported follow-up time. As previously reported by other investigators, the success rate (more than 50% improvement) in our series decreased to approximately 60% at the long-term follow-up of five years. The reason for this is not fully understood by us since these patients were selected for implantation based on their positive response to SNM during PNE testing. However, all patients implanted were severely affected by their urological disorder, which lasted for more than 8.5 years, on average, and for which they had undergone more than 36 surgical procedures without success. If this therapy had not been offered to this group of patients, many of them would have been considered candidates for bladder augmentation or urinary diversion, irreversible surgical procedures. In fact, three out of five SNM treatment failures from this study have already undergone urinary diversion surgery.

It is recognized that one of the challenges of SNM therapy is patient selection. Not all patients with a successful PNE test that uses temporary electrode, show benefit on implantation of a permanent neurostimulator. However, the new technique that requires immediate implant of a permanent tined lead aims to avoid lead migration and allows prolonged patient testing/screening [14]. This testing is much more reliable and ensures a better positive response rate and less re-operations. The percentage of patients proceeding to permanent implantation of the INS is almost doubled when using the tined lead as compared to the temporary PNE test approach [15]. Much research is being done to find more objective parameters that could predict and improve patient outcomes [16]. Considering urodynamic changes clinical results are often better than expected. This may indicate that the urodynamic parameters that we are focused on are not the true parameters to monitor efficacy or the mode of action of SNM.

In our study, when we excluded the two explanted and the one true-failure patient, four UI patients (33%) were completely dry and an additional six (50%) had more than 50% improvement at three year follow-up, when compared to baseline. At five-year follow-up, two (17%) patients remained dry while another eight (67%) had more than 50% improvement, resulting in a total success rate of 83%. When we include all failures, the total success rate (>50% improvement), at five-year follow-up, was 67% (10 out of 15 patients).

The majority of published data on the subject of SNM for urinary disorder reflects only short term results, while only a limited literature on the long term results demonstrates similar success rates as we present here from our institution. Shaker and Hassouna cured 44% of refractory UI patients with SNM; an additional 22% had an average of one leakage episode or less per day. All 18 patients were treated successfully in this study with an average follow-up of 18.8 months [17]. Successful treatment was reported in 68% of 44 patients with refractory UI, three-years post implant by Weil et al. [18]. Bosch and Groen reported a cure rate, defined as more than 90%

improvement in incontinence episodes, in 18 out of 45 patients (40%) with refractory UI with detrusor overactivity and an additional partial success, defined as 50% to 90% improvement in pad use and/or incontinence episodes, in 9 (20%), at an average follow-up of 47.1 months [19]. A greater than 50% improvement in presenting symptoms and quality of life for refractory urinary UI is reported by Latini et al. [20]. A significant decrease in pad use and number of leaking episodes after one-staged or two-staged InterStim Model 3023 (Medtronic Inc., Minneapolis, USA) implants was seen in 90% of patients. The follow-up for this study was relatively short, however.

Treatment was successful in two out of five of our UF patients. For these patients, the voiding frequency had decreased significantly, at five-year follow-up. When we disregard the two explanted failures, dramatic clinical benefit in the other patients was demonstrated (number of voids decreased from 24 to 11), which is congruent with the data previously reported in the literature [5]. A similar clinical outcome was noted by van Voskuilen et al. [21]. In their group of 107 patients treated with SNM for urgency, 63.6% showed a good result. Mean time for follow-up for these patients was 69.8 months.

Our study included only two retention patients of whom one was able to void without clean, intermittent, self-catherization at five-year post implant. SNM treatment in idiopathic non-obstructive chronic urinary retention was reported as successful in all 20 patients studied by Shaker and Hassouna. Post-void residual urine decreased from 78 to 10% of total urinary output at 15 months follow-up [22]. Another study, performed by Vapnek and Schmidt showed clinical success in five of seven patients (71%) with non-obstructive urinary retention [23]. Van Voskuilen found good results in 76.2% of 42 patients treated with implant of a neurostimulator because of non-obstructive urinary retention [21].

Subjective and/or objective clinical benefit of various treatment modalities for voiding dysfunctions are often not supported by significant urodynamic changes [19,24,25]. To better select patients who will benefit from SNM we need to understand its mode/modes of action and know which urodynamic studies correlate with improvement in clinical outcomes. In our study, FSF (first sensation of filling) appeared to be the most subtle parameter to monitor SNM therapy. Predictors of success for SNM therapy have been studied intensively. Recently, Cohen et al. reported on predictors of success for first stage neuromodulation. They concluded that motor response may be a better indicator than sensory response in predicting a positive outcome during intraoperative lead placement of a neurostimulator [26]. Groen et al. published on the urodynamic changes seen after SNM therapy. Using volume independent parameters in women with idiopathic detrusor overactivity, no effects on urethral resistance and bladder contraction strength during voiding were found [27]. For our study in UI patients, we did not discriminate between those with or without detrusor overactivity. However, it is our impression that SNM is more successful in UI patients who do not show detrusor overactivity compared to those with detrusor overactivity (unpublished data).

## Conclusions

---

In recent years, new indications for neuromodulation are being investigated and results look promising [28-34]. To date, SNM is an effective treatment modality that offers sustained clinical benefit in the long term in the majority of selected patients with refractory UI, UF and VD who have failed prior treatments [35,36]. Although the numbers are small, the data presented in this study show that patients with UI seem to benefit the most, when compared to patients with UF and idiopathic VD. Due to very small sample size, no conclusions can be made concerning our VD patients data. Patients were selected for permanent implant when an improvement of > 50% was observed in their main symptoms during PNE test. However, it should be stated that a few patients, even though successfully trialed with PNE, will have long-term failures.

## References

---

1. Kelleher CJ, Cardozo LD, Khullar V et al. A medium-term analysis of the subjective efficacy of treatment for women with detrusor instability and low bladder compliance. *Br J Obstet Gynaecol* 1997; 104: 988-993
2. Consumer Focus: A survey of Community Dwelling Incontinent People. National Association for Continence, 1996
3. Tanagho EA and Schmidt RA. Electrical stimulation in the clinical management of the neurogenic bladder. *J Urol* 1988; 140: 1331-1339
4. Bemelmans BLH, Mundy AR and Craggs MD. Neuromodulation by implant for treating lower urinary tract symptoms and dysfunction. *Eur Urol* 1999; 36: 81-99
5. Hassouna MM, Siegel SW, Lycklama \_ Nijeholt AAB et al. Sacral Neuromodulation in the treatment of urgency-frequency symptoms: a multicenter study on efficacy and safety *J Urol* 2000; 163: 1849-1854
6. Swinn MJ, Kitchen ND, Goodwin RJ, Fowler CJ. Sacral Neuromodulation for women with Fowler's syndrome. *Eur Urol* 2000; 38: 439-443
7. Schmidt RA, Jonas U, Oleson KA et al. Sacral nerve stimulation for treatment of refractory urinary urge incontinence. *J Urol* 1999; 162(2): 352-357
8. Schmidt RA. Advances in genitourinary neurostimulation. *Neurosurgery* 1986; 19: 1041-1044
9. Thon WF, Baskin LS, Tanagho EA and Schmidt RA. Neuromodulation of voiding dysfunction and pelvic pain. *World J Urol* 1991; 9: 138-141
10. Hohenfellner M, Thüroff JW, Schultz-Lampel D, Schmidt RA and Tanagho EA. Sakrale Neuromodulation zur therapie von Miktionsstörungen. *Aktuelle Urologie* 1992; 23: I-X
11. Elabbady AA, Hassouna MM and Elhilali MM. Neural stimulation for chronic voiding dysfunctions. *J Urol* 1994; 152: 2076-2080
12. Bosch JLHR and Groen J. Sacral (S3) segmental nerve stimulation as a treatment for urge incontinence in patients with detrusor instability: results of chronic electrical stimulation using an implantable neural prothesis. *J Urol* 1995; 154: 504-507
13. Janknegt RA, Hassouna MM, Siegel SW et al. Long-Term Effectiveness of Sacral Nerve Stimulation for Refractory Urge Incontinence. *Eur Urol* 2001; 39: 101-106
14. Kessler TM, Buchser E, Meyer S, Engeler DS, Al-Khodayry AW, Bersch U et al. Sacral neuromodulation for refractory lower urinary tract dysfunction: results of a nationwide registry in Switzerland. *Eur Urol* 2007; 51 :1357-1363
15. Peters KM, Carey JM, Konstandt DB. Sacral neuromodulation for the treatment of refractory interstitial cystitis: outcome based on technique. *Int Urogynecol J Pelvic Floor Dysfunct* 2003; 14: 223-228
16. Benson JT. Sacral nerve stimulation results may be improved by electrodiagnostic techniques. *Int. Urogynecol J. Pelvic Floor Dysfunct* 2000; 11: 352-357
17. Shaker HS and Hassouna MM. Sacral nerve root neuromodulation: an effective treatment for refractory urge incontinence. *J Urol* 1998; 159: 1516-1519
18. Weil EHJ, Ruiz-Cerda JL, Eerdmans PHA, Janknegt RA, Bemelmans BLH and van Kerrebroeck PhEV. Sacral root neuromodulation in the treatment of refractory urinary urge incontinence: a prospective randomized clinical trial. *Eur Urol* 2000; 37: 161-171
19. Bosch JHLR and Groen J. Sacral nerve neuromodulation in the treatment of patients with refractory motor urge incontinence: long-term results of a prospective longitudinal study. *J Urol* 2000; 163: 1219-1222

20. Latini JM, Alipour M and Kreder Jr KJ. Efficacy of sacral neuromodulation for symptomatic treatment of refractory urinary urge incontinence. *Urology* 2006; 67(3): 550-553
21. van Voskuilen AC, Oerlemans DJ, Weil EH, de Bie RA and van Kerrebroeck PE. Long term results of neuromodulation for lower urinary tract symptoms: a retrospective single center study. *Eur Urol* 2006; 49(2) :366-372
22. Shaker HS and Hassouna M. Sacral root neuromodulation in idiopathic nonobstructive chronic urinary retention. *J Urol* 1998; 159: 1476-1478
23. Vapnek J and Schmidt RA. Restoration of voiding in chronic urinary retention using the neuroprosthesis. *World J Urol* 1991; 9: 142-144
24. Tapp A, Fall M, Norgaard J et al. Tolterodine: a dose titrated, multicenter study of the treatment of the of idiopathic detrusor instability in women. *J Urol* 1989; 142: 1027
25. Zeegers AGM, Kieswetter H, Kramer AEJL et al. Conservative therapy of frequency, urgency, and urge incontinence: a double blind clinical trial of flavoxate hydrochloride, oxybutinine chloride, emepronium bromide and placebo. *World J Urol* 1987; 5: 57
26. Cohen BL, Tunuguntla HSGR and Gousse A. Predictors of success for first stage neuromodulation: motor versus sensory response. *J Urol* 2006; 175: 2178-2181
27. Groen J, Bosch JLHR and van Mastrigt R. Sacral neuromodulation in women with idiopathic detrusor overactivity incontinence: decreased overactivity but unchanged bladder contraction strength and urethral resistance during voiding. *J Urol* 2006; 175: 1005-1009
28. Bosch JLHR, Groen J. Treatment of refractory urinary urge incontinence with sacral spinal nerve stimulation in multiple sclerosis patients. *Lancet* 1996; 398: 717-719
29. Chai TC, Zhang C, Warren JW, Keay S. Percutaneous sacral third nerve root neurostimulation improves symptoms and normalizes urinary HB-EGF levels and antiproliferative activity in patients with interstitial cystitis. *Urology* 2000; 55(5): 643-646
30. Chartier-Kastler EJ, Bosch JLHR, Perrigot M, Chancellor MB, Richard F, Denys P. Long-term results of sacral nerve stimulation (s3) for the treatment of neurogenic refractory urge incontinence related to detrusor hyperreflexia. *J Urol* 2000; 164: 1476-1480
31. Matzel KE, Stadelmaier U, Hohenfellner M, Hohenberger W. Chronic sacral spinal nerve for fecal incontinence: long-term results with foramen and cuff electrodes. *Dis Colon Rectum* 2001; 44: 59-66
32. Feler CA, Whitworth LA, Fernandez J. Sacral neuromodulation for chronic pain conditions. *Aesthesiol Clin North America* 2003; 21(4): 785-795
33. Whitmore KE, Payne CK, Diokno AC, Lukban JC. Sacral neuromodulation in patients with interstitial cystitis: a multicenter clinical trial. *Int Urogynecol J Pelvic Floor Dysfunction* 2003; 14(5): 305-308
34. Comiter CV. Sacral neuromodulation for the symptomatic treatment of refractory interstitial cystitis: a prospective study. *J Urol* 2003; 169(4): 1369-1373
35. Abrams P, Blaivas JG, Fowler CJ, Fourcroy JL, Macdiarmid SA, Siegel SW, van Kerrebroeck P. The role of neuromodulation in the management of urinary urge incontinence. *BJU Int* 2003; 91(4): 355-359
36. Aboseif S, Tamaddon K, Chalfin S, Freedman S, Mourad MS, Chang JH, Kaptein JS. Sacral neuromodulation in functional urinary retention: an effective way to restore voiding. *BJU Int* 2002; 90(7): 662-665

