NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE

INTERVENTIONAL PROCEDURES PROGRAMME

Interventional procedure overview of sacral nerve stimulation for idiopathic chronic non-obstructive urinary retention

Urinary retention is the inability to empty the bladder. It most often happens because of some kind of physical obstruction like an enlarged prostate, but sometimes it occurs without any obstruction. Sacral nerve stimulation is done by implanting a small device just beneath the skin, usually in the upper buttock. This sends electrical impulses to nerves in the lower back, to help the patient regain control of their bladder function.

Introduction

The National Institute for Health and Care Excellence (NICE) has prepared this interventional procedure (IP) overview to help members of the Interventional Procedures Advisory Committee (IPAC) make recommendations about the safety and efficacy of an interventional procedure. It is based on a rapid review of the medical literature and specialist opinion. It should not be regarded as a definitive assessment of the procedure.

Date prepared

This IP overview was prepared in March 2015.

Procedure name

- Sacral nerve stimulation for idiopathic chronic non-obstructive urinary retention

Specialist societies

- British Society of Urogynaecology
- British Association of Urological Surgeons
- Neuromodulation Society of the United Kingdom and Ireland
- British Association of Spinal Cord Injury Specialists.

Description

Indications and current treatment

Non-obstructive urinary retention is the inability to empty the bladder with no physical obstruction to the urine flow. It can occur as a result of neurological disorders, such as multiple sclerosis or spinal cord disease, or it can be idiopathic. In younger women, it may be caused by Fowler's syndrome, which is a rare disorder in which the urethral sphincter fails to relax to allow urine to be passed normally. Non-obstructive urinary retention can cause complications such as recurrent urinary tract infections and chronic kidney disease.

Initial management in men is usually with drug therapy, such as alpha blockers, and urethral dilatation; whereas in women it is usually urethral dilatation only. The efficacy of both these options is limited and most patients will need to do clean intermittent self-catheterisation or to have an indwelling catheter. If these measures are insufficient, then the only surgical options were urinary diversion procedures. Sacral nerve stimulation has been introduced as an option for patients with non-obstructive urinary retention that is refractory to conservative treatment.

What the procedure involves

Sacral nerve stimulation for chronic non-obstructive urinary retention involves applying an electric current to one of the sacral nerves via an electrode placed through the corresponding sacral foramen. It aims to restore the ability to empty the bladder voluntarily and to eliminate the need for catheterisation. The precise mechanism of action is not fully understood.

Sacral nerve stimulation involves an initial evaluation phase to help the patient and physician determine if long-term therapy will be beneficial and also to assess the integrity of the sacral nerves and to identify the optimal lead location. Two main techniques are used for this evaluation, both of which are done using fluoroscopic guidance, with the patient under general or local anaesthesia. The conventional technique involves percutaneously placing a temporary lead, with a unipolar electrode, alongside a sacral nerve (usually S3) and taping it to the skin surface. A newer 2-stage technique involves implanting a permanent tined lead, with a quadripolar electrode, on the sacral nerve through the third sacral foramen. When the lead is correctly positioned, an extension cable is tunnelled to the proposed site for possible future neurostimulator placement, usually in the upper buttock. The lead is then tunnelled to the contralateral buttock to provide a remote exit site through the skin.

In both techniques, the leads are attached to a small, external neurostimulator and the level of stimulation is adjusted to achieve normal voiding of urine whilst avoiding discomfort for the patient. The length of the evaluation varies but is generally around 3–7 days with the temporary lead method and approximately 2–4 weeks if a permanent lead is used.

Once the initial evaluation phase is complete, implantation of the pulse generator (sacral nerve neurostimulator) is done, usually with the patient under general anaesthesia. The neurostimulator is inserted into a subcutaneous pocket through a small incision in the upper buttock. If a permanent lead was used in the evaluation phase, it is connected to the neurostimulator. If a temporary lead was used, it is replaced by a permanent lead placed in approximately the same position and connected to the neurostimulator. The electrical stimulation, generated by the neurostimulator and delivered via the lead, modifies sacral nerve activity. The patient can control the neurostimulator with a hand-held programmer, increasing or decreasing the level of stimulation or turning it on and off.

Literature review

Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to sacral nerve stimulation for idiopathic chronic non-obstructive urinary retention. Searches were conducted of the following databases, covering the period from their commencement to 2 March 2015: MEDLINE, PREMEDLINE, EMBASE, Cochrane Library and other databases. Trial registries and the Internet were also searched. No language restriction was applied to the searches (see appendix C for details of search strategy). Relevant published studies identified during consultation or resolution that are published after this date may also be considered for inclusion.

The following selection criteria (table 1) were applied to the abstracts identified by the literature search. Where selection criteria could not be determined from the abstracts the full paper was retrieved.

Table 1 Inclusion criteria for identification of relevant studies

Characteristic	Criteria
Publication type	Clinical studies were included. Emphasis was placed on identifying good quality studies. Abstracts were excluded where no clinical outcomes were reported, or where the paper was a review, editorial, or a laboratory or animal study. Conference abstracts were also excluded because of the difficulty of appraising study methodology, unless they reported specific adverse events that were not available in the published literature.
Patient	Patients with idiopathic chronic non-obstructive urinary retention.
Intervention/test	Sacral nerve stimulation.
Outcome	Articles were retrieved if the abstract contained information relevant to the safety and/or efficacy.
Language	Non-English-language articles were excluded unless they were thought to add substantively to the English-language evidence base.

List of studies included in the IP overview

This IP overview is based on approximately 969 patients from 1 systematic review including 1 RCT and 13 observation studies (the RCT and 1 of the observation studies have been summarised in detail in table 2), and an additional 3 case series[1–6].

Other studies that were considered to be relevant to the procedure but were not included in the main extraction table (table 2) have been listed in appendix A.

Table 2 Summary of key efficacy and safety findings on sacral nerve stimulation for idiopathic chronic non-obstructive urinary retention

Study 1 Gross C (2010)

Details

Study type	Systematic review and meta-analysis
Country	USA
Recruitment period	Publication dates 1980–2008
Study population and number	Patients with nonobstructive urinary retention. 14 studies were included in the systematic review (1 RCT and 13 observational studies, n=751)
Age and sex	Not reported
Patient selection criteria	Excluded criteria were neurogenic aetiology (such as spinal cord injury, diabetes, multiple sclerosis) for urinary retention and non-English studies.
Technique	Sacral neuromodulation using implanted generators with permanent lead placement.
Follow-up	**13 of the 14 studies followed patients for a minimum of 6 months; 1 study followed patients for only 10 days.**
Conflict of interest/source of funding	Not reported

Analysis

Follow-up issues: 13 of the 14 studies had a 75% or greater follow-up rate.

Study design issues: The primary outcomes assessed were the change in pre- and postoperative postvoid residual and voided volume. A dataset addressing the primary outcomes was obtained for 7 studies (1 RCT and 6 observational studies) and used in the final analysis. Some of the included studies used unilateral lead placement and some used bilateral lead placement. Most studies used the traditional percutaneous nerve evaluation technique rather than the newer 2-stage technique. Many of the included studies were funded by or the primary investigators were consultants for Medtronic, which is the company that manufactures Interstim.

Other issues: The review states that only 7 of the 14 papers provided suitable data for analysis, which included a total of 478 patients. In the discussion, the authors state that the total number of patients for the analysis was 751 but the numbers for each study are not tabulated. It notes that the number of patients for the majority of the papers was less than 30. With regard to safety outcomes, the paper states that all 14 studies provided data and uses a denominator of 1239 patients. It is likely that this includes patients with indications other than non-obstructive urinary retention.

Key efficacy and safety findings

Efficacy

Number of patients analysed: **478**

Study	Mean follow-up (months)	Mean age (y)	N	Mean preop post-void residual (PVR, ml)	Mean postop PVR (ml)	Mean preop voided volume (ml)	Mean postop voided volume (ml)
Jonas et al. (RCT)	6*	43	51 (29 vs 22)	339	49**	138	242#
Elabbady et al.	6	29	8	395	173	70	422
Everaert et al.	31	43	15	582	56	NR	NR
Scheepens et al.	59$	53	15	303	71	153	353
Siegel et al.	18	43	177	343	91	NR	NR
Van Kerrebroeck et al.	60	45	163	380	109	NR	NR
Van Voskuilen et al.	16	50	49	298	112	123	248

*The systematic review states this as being 18 months but the original paper reports these particular results at 6 months follow-up. Efficacy results from the 51 patients in the RCT were reported at 6 months; results at 18 months follow-up were available for a total of 24 patients with implants.

$ The text states that this study only followed patients up for 10 days.

**95% CI:179–360 ml, p<0.00001, #95% CI: 55–152 ml, p<0.0001

The mean difference in postvoid residual was 236 ml (95% CI: 219–253 ml, p<0.00001, I^2=83%) favouring sacral nerve stimulation.

The mean difference in voided volume was 344 ml (95% CI: 322–365 ml, p<0.00001, I^2=97%) favouring sacral nerve stimulation.

All but 2 of the studies in the review used the percutaneous nerve evaluation technique for lead implantation. The review notes that Scheepens et al. reported that the 2-stage implantation technique was clinically and statistically superior to percutaneous nerve evaluation. The authors suggest that the potential problem with percutaneous nerve evaluation is that the lead can become displaced during the testing phase and the testing phase is much shorter than that for the newer 2-stage implantation technique, which may result in a high false-negative rate.

Safety

The paper states that all 14 of the included studies provided data on postoperative complications but it also states that complications were not reported for the Von Voskuilen study..

- Pain at implant site=10.3% (128/1239)
- Lead migration=4.8%
- Infection=4.4%
- New pain=4.3%
- Pain at the lead site=1.9%
- Sensation of electrical shock=1.9%

Abbreviations used: NR, not reported; PVR, postvoid residual

Study 2 Jonas U (2001) – also included in systematic review (study 1)

Details

Study type	Randomised controlled trial
Country	USA
Recruitment period	1993–8
Study population and number	**n=177 patients enrolled in the study; 68 (38%) qualified for implantation of sacral nerve stimulation system (37 early implantation versus 31 delayed implantation and standard medical treatment)** Patients with idiopathic urinary retention.
Age and sex	Mean age 43 years; 74% female
Patient selection criteria	Age older than 16 years; refractory to standard medical therapy; minimum 100 ml bladder capacity with normal upper urinary tract; good surgical candidate; able to complete study documentation and return for follow up evaluation. Exclusion criteria: neurological condition, including multiple sclerosis, diabetes with peripheral nerve involvement, spinal cord injury and stroke; stress urinary incontinence; primary pelvic pain.
Technique	Percutaneous test stimulation procedure was done in all 177 patients for 3–7 days. A sacral nerve stimulation system (Interstim, Medtronic Inc., USA) was implanted in patients with a greater than 50% improvement in baseline voiding symptoms during test stimulation. Patients in the treatment group had early implantation of the system and patients in the control group had the system implanted 6 months later.
Follow-up	**6 months for RCT, 18 months for all patients with implants.**
Conflict of interest/source of funding	4 authors had financial interest and/or other relationship with a number of companies, including Medtronic.

Analysis

Follow-up issues: 3 patients were lost to follow-up at 6 months; an additional 8 patients did not return a voiding diary and 6 patients had not yet been enrolled for 6 months at the time of data collection. Voiding diaries were available for 21 patients at 18 months follow-up; data were also included from an additional 3 patients who had withdrawn from the study because of lack of efficacy (n=2) or an adverse event (n=1).

Study design issues: Voiding diaries used to quantify the effects of sacral nerve stimulation on urinary retention were the primary outcome measure of the study. A 'therapy evaluation test' was done 6 months after implant, which consisted of deactivating stimulation for a minimum of 3 days before reactivation. Urodynamic tests were conducted at baseline and 6 months after implant.

Study population issues: 86% (153/177) of patients had received pharmacological treatment, including α blockers, β blockers and antibiotics, 35% (62/177) had undergone a total of 271 nonsurgical interventions, including biofeedback, urethral dilations, psychological counselling and timed voiding, and 47% (83/177) had undergone a total of 239 surgical interventions, including hysterectomy, prostate surgery, cystocele repair and bladder neck suspension for treatment of voiding disorders before the study.

Key efficacy and safety findings

Efficacy

Number of patients analysed: **51 (29 versus 21)**

Voiding diary results at baseline versus 6 months (mean±standard deviation)

Diary variable	Sacral nerve stimulation (n=29)		Control (n=22)		p value*
	Baseline	6 months	Baseline	6 months	
Catheter volume/catheterisation (ml)	339±176	49±106	350±152	319±195	<0.0001
Number of catheterisations/day	5.7±3.1	1.4±2.6	4.0±1.7	3.9±2.2	<0.0001
Total catheter volume/day (ml)	1744±1047	237±564	1379±845	1305±890	<0.0001
Maximum catheter volume (ml)	613±461	72±145	563±276	484±292	<0.0001
Number of voids/day	4.0±4.9	6.5±3.1	3.2±4.1	2.9±4.3	0.002
Total volume voided/day (ml)	722±1036	1808± 879	560±769	488±730	<0.0001

* comparing mean differences

Therapy evaluation results (n=34, mean±standard deviation) – the stimulator was deactivated for a minimum of 3 days before reactivation

Diary variable	6 months follow-up (stimulation on)	therapy evaluation (stimulation off)	p value
Catheter volume/catheterisation (ml)	77±137	264±153	<0.0001
Number of catheterisations/day	1.5±2.5	4.6±2.9	<0.0001
Total catheter volume/day (ml)	259±554	1360±984	<0.001
Maximum catheter volume (ml)	112±191	374±224	<0.0001
Number of voids/day	6.8±3.1	4.2±5.6	0.003
Total volume voided/day (ml)	1767±800	648±889	<0.0001

Catheter volume per catheterisation at 18 months follow-up:

- No catheterisation=58% (14/24)
- Significant reduction (50% or more reduction in catheter volume per catheterisation)=13%
- Slight reduction (less than 50% reduction in catheter volume per catheterisation)=13%
- No reduction (no change or slight increase)=4%
- Device explanted=4%
- Lack of efficacy=9%

Safety

Safety data were based on a total of 219 patients with an implanted sacral nerve stimulation system – it is not clear from the paper how these patients were identified and what the indications for treatment were.

Patients were followed up for a mean of 17.6 months.

Complications with incidence greater than 5%:

- Pain at neurostimulator site=15.3%
- New pain=9%
- Suspected lead migration=8.4%
- Infection=6.1%
- Transient sensation of electrical shock=5.5%
- Pain at lead site=5.4%

There were no reports of serious adverse device effects or permanent injury associated with the implantable components.

Study 3 Datta SN (2008) – also included in systematic review (study 1)

Details

Study type	**Case series**
Country	UK
Recruitment period	1996–2006
Study population and number	**n=60** Women with urinary retention
Age and sex	Mean age 37 years; 100% female
Patient selection criteria	History of voiding dysfunction with complete or partial retention, elevated urethral pressure profilometry (UPP, >100 cmH_2O), increased urethral sphincter volume (SV_1>1.8 ml) and abnormal urethral sphincter electromyography (EMG, complex repetitive discharges and decelerating bursts).
Technique	30 patients had a 1-stage procedure, involving percutaneous nerve evaluation for 4–7 days. If successful, this was followed by open surgery with bone suture fixation of the electrode, and with an extension lead tunnelled to the abdomen where the implantable pulse generator (IPG) was placed. The other 30 patients had a 2-stage procedure with initial insertion under general anaesthesia of a tined electrode. The testing period lasted about 4 weeks, after which the IPG was implanted in the buttock if the testing period was successful. Device: Interstim®, Medtronic Inc, UK.
Follow-up	**Mean 4 years**
Conflict of interest/source of funding	None

Analysis

Follow-up issues: No patients were lost to follow-up.

Study design issues: Case records were reviewed for all patients, for the length of follow-up, return to voiding and need for catheterisation, complications and number of reoperations. Patients treated by a 1-stage technique had a longer mean follow-up than those treated by a 2-stage technique (84 versus 12 months). The 1-stage group were selected from 125 patients screened with a percutaneous nerve evaluation, of whom 53 were judged a success. In the 2-stage group, 8 patients had a previous negative percutaneous nerve evaluation, but 5 of these had a successful outcome with the 2-stage procedure.

Other issues: The authors note that the 2-stage technique is now the preferred standard rather than the percutaneous nerve evaluation followed by the 1-stage implant. Although this study was identified for inclusion in the systematic review, data from the study were not included in the efficacy analysis.

Key efficacy and safety findings

Efficacy

Number of patients analysed: **60**

Efficacy of sacral nerve stimulation by procedure

	1-stage n=30	2-stage n=30	Total
Spontaneous voiding, n (%)	21 (70)	22 (73)	43 (72)
number also needing CISC, n (%)	5 (17)	8 (27)	13 (22)
Mean postvoid residual volume (ml) (in voiders)	85.7	113.6	100
Successful PNE	30/30 (100)	21/29 (72)	51/59 (86)
Voiding	53%	46%	50%
CISC assisted voiding	17%	27%	22%
Not voiding	30%	27%	28%
Stimulator removed, n (%)	7 (23)	5 (17)	12 (20)

In the 2-stage group, 8 patients had a previous negative percutaneous nerve evaluation, but 5 of these had a successful outcome with the 2-stage procedure.

In the 33 women with an abnormal urethral sphincter electromyography (EMG), 25 (76%) had restoration of voiding compared against 3 out of 7 women with a normal EMG.

3 patients in the 1-stage group failed to respond to the sacral nerve stimulator, which was then removed. They all subsequently responded successfully to a 2-stage procedure. 2 patients in the 2-stage group had no response to tined lead stimulation and had the electrode removed.

The mean battery life in 9 women who developed loss of sensation or intermittency secondary to confirmed IPG failure was 7.31 (4.0–8.9) years.

Safety

There were 99 adverse events in 60 patients and 63 surgical revisions during a total of 2878 months of sacral nerve stimulation experience (14 patients had more than 1 revision [range 2–8]).

- Serious adverse events (defined as 1 that needed hospital admission or surgical revision to resolve)=74 (52 in the 1-stage group and 22 in the 2-stage group)
- Minor adverse events=25 (9 in the 1-stage group and 16 in the 2-stage group)
- Lead migration=28% (17/60) (15 were in the 1-stage group and 2 in the 2-stage group)

Frequency of complications (n, estimated from graph)

Complication	1-stage procedure	2-stage procedure
Box site pain	15	4
Loss of response	9	9
Lead problems	17	3
Leg pain	10	8
Urinary tract infection	3	2
Wound	4	2
Pelvic pain	1	1
Urethral pain	0	2

Abbreviations used: CISC, clean intermittent self-catheterisation; EMG, electromyography; PNE, percutaneous nerve evaluation

Study 4 White WM (2008)

Details

Study type	**Case series (retrospective)**
Country	USA
Recruitment period	2000–7
Study population and number	**n=40** Patients with refractory, nonobstructive urinary retention (29 complete retention, 11 incomplete)
Age and sex	Mean age 51 years
Patient selection criteria	Objective evidence of nonobstructive urinary retention refractory to standard medical therapy.
Technique	Staged sacral nerve stimulation lead placement with the Interstim® device (Medtronic, USA). Patients with greater than 50% improvement in symptoms according to the 1-week follow-up voiding diary underwent placement of an implantable pulse generator.
Follow-up	**Mean 40 months**
Conflict of interest/source of funding	Not reported

Analysis

Follow-up issues: No losses to follow-up were described.

Study design issues: Patients were followed up postoperatively, and outcome data obtained (number of daily catheterisations and volume per catheterisation for patients with complete retention, and the mean postvoid residual urine volume for patients with incomplete retention.

Study population issues: Aetiology of retention was idiopathic in 28 (70%), incomplete spinal cord injury in 5 (12.5%), secondary to pelvic surgery in 4 (10%) and Fowler syndrome in 3 (7.5%)

Key efficacy and safety findings

<table>
<tr><th>Efficacy</th><th>Safety</th></tr>
<tr><td>
Number of patients analysed: 40

Of the 40 patients who had staged test stimulation, 28 (70%) had greater than 50% improvement in symptoms according to the 1-week follow-up voiding diary and subsequently had a neurostimulator implanted.

20/29 (69%) patients with complete retention had a successful response, and 8/11 (73%) patients with incomplete retention.

The only preoperative predictor of a successful outcome was the presence of Fowler syndrome (3 out of 3 patients with Fowler syndrome had a successful response).

Success of sacral nerve stimulation according to voiding parameters, n=28 (mean±standard deviation)
<table>
<tr><th>Voiding diary variable</th><th>Baseline</th><th>Follow-up</th><th>p value</th></tr>
<tr><td colspan="4">Complete retention*</td></tr>
<tr><td>Daily catheterisations (n)</td><td>4.3±1.66</td><td>1±1.26</td><td><0.001</td></tr>
<tr><td>Volume/catheterisation (ml)</td><td>340.8±237.8</td><td>93.8±144.2</td><td><0.001</td></tr>
<tr><td colspan="4">Incomplete retention**</td></tr>
<tr><td>Postvoid residual urine volume (ml)</td><td>333.5±148.2</td><td>87.4±72.9</td><td><0.001</td></tr>
</table>
* Mean follow-up=41.4±22.3 months
** Mean follow-up=31.8±14.7 months

At a mean follow-up of 40 months (range 3–67), 86% (24/28) of patients reported functioning devices with sustained improvement of more than 50% according to the 1-week follow-up voiding diary.

55% (11/20) of patients with complete retention were able to eliminate catheterisation completely.
</td><td>

Device removal=14.3% (4/28), 2 because of infection, 1 because of pain and 1 because of the need for MRI.
Neurostimulator revision=21.4% (6/28), battery expiration or device malfunction=4, infection=2.
Infection=14.3% (4/28)

Note: the authors state that there were a total of 6 infectious complications among 250 patients treated by sacral nerve stimulation in their centre, giving an overall rate of 2.4%.
</td></tr>
</table>

Study 5 Peeters K (2014)

Details

Study type	**Case series (retrospective)**
Country	Belgium
Recruitment period	1996–2010
Study population and number	**n=93** Patients with idiopathic retention (including 32 patients with Fowler's syndrome)
Age and sex	Mean age=44 years for patients with Fowler's syndrome and 48 years for patients without Fowler's syndrome; 93% (86/93) female
Patient selection criteria	Not reported
Technique	18 patients had the implant located in the abdomen rather than the buttock. Before 2004, the permanent lead was implanted using an open surgical technique with an incision made in the midline over the sacrum. The lead was placed under direct vision (n=43). The technique then changed to a self-anchoring tined lead, which was placed percutaneously. The evaluation lasted 3 days. Device – Interstim (Medtronic, USA)
Follow-up	**Mean 91 months (patients with Fowler's syndrome) and 60 months (patients without Fowler's syndrome)**
Conflict of interest/source of funding	The first author has no conflicts of interest; 2 authors are consultants for a number of companies including Medtronic, AMS, Astellas, Allergan and Pfizer.

Analysis

Study design issues: The report also included data from patients with other indications (including urgency incontinence and urgency frequency syndrome).

Study population issues: 22 patients had an indwelling catheter; 69 were using clean intermittent self-catheterisation.

Key efficacy and safety findings

Efficacy	Safety
Number of patients analysed: 93 Success was defined as reduction of >50% in the intermittent self-catheterisation rate with 100% success being no intermittent self-catheterisation and no voiding dysfunction. Success rate=73% Cure rate or 100% success=62.5% for patients with Fowler's syndrome and 53% for patients with non-Fowler's idiopathic urinary retention. Percentage success in 32 patients with Fowler's syndrome: • 50-69%=4% • 70-79%=12.5% • 80-99%=21% • 100%=62.5% Percentage success in 61 patients with non-Fowler's idiopathic urinary retention: • 50-69%=31% • 70-79%=11% • 80-99%=4% • 100%=54% Psychiatric comorbidity did not have an impact on successful outcome (p=0.4)	Postoperative complications (in the 93 patients with urinary retention) • Wound seroma=1.1% (1/93) • Infection treated with antibiotics=2.2% (2/93) • Infection needing explant=2.2% (2/93) Of the total 217 patients treated by sacral nerve stimulation for lower urinary tract dysfunction, there were 88 (41%) patients who had at least 1 device or therapy related reintervention. • Device explantation=18% (39/217), 25 for treatment failure, 4 for infection, 3 for pain at the implant site or due to the lead, 3 at request of the patient or the need for MRI, 4 for device malfunction. • Lead repositioning for poor efficacy and suspected migration or pain=22% (48/217) • Device repositioning because of pain at the implant site=5.1% (11/217) • Battery depletion with exchange of battery=10.1% (22/217) Lead repositioning was necessary in 25 patients implanted with the old lead (42%) and in 23 implanted with the newer percutaneous placed tined lead (15%, p<0.001). Device explantation and repositioning was necessary in 23% and 12% of patients with the open technique compared with 16% and 3% with the tined lead.

Efficacy

Success rate

A case series of 40 patients reported that 69% (20/29) of patients with complete retention and 73% (8/11) of patients with incomplete retention had a successful response to sacral nerve stimulation[4]. A case series of 93 patients with idiopathic urinary retention reported a success rate of 73%; the cure rate (100% success) was 62.5% for patients with Fowler's syndrome and 53% for patients with non-Fowler's idiopathic urinary retention[5].

Post-void residual volume

A systematic review of 14 articles reported post-void residual volume from 7 articles (n=478). The mean difference in volume decreased 236 ml (95% CI: 219 to 253, $p<0.0001$, $I^2=83\%$) after sacral nerve stimulation[1]. A randomised controlled trial (RCT) of 51 patients with idiopathic urinary retention treated by sacral nerve stimulation or standard medical treatment, which was also included in the systematic review, reported that the mean catheter volume per catheterisation decreased from 339 ml to 49 ml at 6 months' follow-up in the treatment group and from 350 ml to 319 ml in the control group ($p<0.0001$ comparing the mean differences)[2]. The case series of 40 patients reported that the mean post-void residual urine volume decreased from 333.5 ml to 87.4 ml after a mean follow-up of 32 months, in 8 patients with incomplete urinary retention[4].

Voided volume

The systematic review of 14 articles reported voided volume from 7 articles (n=478). The mean voided volume increased by 344 ml (95% CI: 322 to 365, $p<0.0001$, $I^2=97\%$) after sacral nerve stimulation. The RCT of 51 patients reported that the mean total voided volume per day increased from 722 ml to 1808 ml at 6 months' follow-up in the treatment group and decreased from 560 ml to 488 ml in the control group ($p<0.0001$ comparing the mean differences)[2].

Catheterisation

The RCT of 51 patients reported that the mean number of catheterisations per day decreased from 5.7 to 1.4 at 6 months' follow-up in the treatment group and from 4.0 to 3.9 in the control group ($p<0.0001$ comparing the mean differences)[2]. 58% (14/24) of patients treated by sacral nerve stimulation did not need catheterisation at 18 months' follow-up. A case series of 60 patients reported that 72% (43/60) of patients were voiding spontaneously and 50% (30/60) of patients no longer needed to use catheterisation after a mean follow-up of 4 years[3]. The

case series of 40 patients reported that the mean number of catheterisations per day decreased from 4.3 to 1.0 after a mean follow-up of 41 months and 55% (11/20) of patients with complete retention were able to eliminate catheterisation completely[4].

Safety

Device removal/surgical revision

The neurostimulator device was removed in 14.3% (4/28) of patients in a case series of 40 patients: 2 were removed because of infection, 1 because of pain and 1 because of the need for MRI[4]. In the same study, neurostimulator revision was necessary in 21.4% (6/28) of patients: battery expiration or device malfunction occurred in 4 patients and infection in 2 patients. Device removal because of infection was reported in 2.2% (2/93) of patients in a case series of 93 patients[5]. There were 63 surgical revisions in the case series of 60 patients, during a total of 2878 months of sacral nerve stimulation[3]. Device removal was reported in 4% of patients treated by sacral nerve stimulation at 18 months' follow-up in a RCT of 51 patients[2].

Lead migration

Lead migration was reported in 4.8% of patients in a systematic review of 14 articles[1]. Lead migration was reported in 28% (17/60) of patients in a case series of 60 patients, 15 of which were in the group of 30 patients who had a 1-stage procedure for implanting the neurostimulator[3].

Pain

Pain at the implant site and pain at the lead site were reported in 10.3% (128/1239) and 1.9% of patients respectively, in the systematic review[1]. New pain was reported in 4.3% of patients in the same review. Pain at the implant site was reported in 31.7% (19/60) of patients in the case series of 60 patients[3]. Leg pain, pelvic pain and urethral pain were reported in 30% (18/60), 3.3% (2/60) and 3.3% (2/60) of patients respectively, in the same study[3]. Pain at the neurostimulator site was reported in 5.9% (2/34) of patients in the case series of 85 patients. In the same study, new pain was reported in 11.8% (4/34) of patients.

Infection

Infection was reported in 4.4% of patients in the systematic review[1]. Urinary tract infection was reported in 8.3% (5/60) of patients in the case series of 60 patients[3]. Infection was reported in 14.3% (4/28) of patients in the case series of 40 patients[4]. Infection that was successfully treated with antibiotics was reported in 2.2% (2/93) of patients in a case series of 93 patients[5].

Sensation of electric shock

Sensation of electric shock was reported in 1.9% of patients in the systematic review[1].

Wound seroma

Wound seroma was reported in 1 patient in the case series of 93 patients[5].

Validity and generalisability of the studies

- The evidence consists mainly of small case series; there is 1 small RCT of 51 patients treated by sacral nerve stimulation or medical management.
- The RCT excluded patients with a neurological condition[2].
- The efficacy of sacral nerve stimulation may differ according to the aetiology of the urinary retention.
- The technique of implantation and the type of electrode used varies within and between studies. All but 2 studies included in the systematic review used the 1-stage percutaneous nerve evaluation method of lead implantation – the authors note that 1 of the studies that used the 2-stage implantation technique reported clinically and statistically superior results compared with the 1-stage technique[1].

Existing assessments of this procedure

There were no published assessments from other organisations identified at the time of the literature search.

Related NICE guidance

Below is a list of NICE guidance related to this procedure. Appendix B gives details of the recommendations made in each piece of guidance listed.

Interventional procedures

- Sacral nerve stimulation for urge incontinence and urgency-frequency. NICE interventional procedure guidance 64 (2004). Available from http://www.nice.org.uk/guidance/IPG64
- Sacral nerve stimulation for faecal incontinence. NICE interventional procedure guidance 99 (2004). Available from http://www.nice.org.uk/guidance/IPG99

NICE guidelines

- Lower urinary tract symptoms: The management of lower urinary tract symptoms in men. NICE clinical guideline 97 (2010). Available from http://www.nice.org.uk/guidance/CG97
- Urinary incontinence in neurological disease: Management of lower urinary tract dysfunction in neurological disease. NICE clinical guideline 148 (2012). Available from http://www.nice.org.uk/guidance/CG148
- Urinary incontinence: The management of urinary incontinence in women. NICE clinical guideline 171 (2013). Available from http://www.nice.org.uk/guidance/CG171

Specialist advisers' opinions

Specialist advice was sought from consultants who have been nominated or ratified by their Specialist Society or Royal College. The advice received is their individual opinion and is not intended to represent the view of the society. The advice provided by Specialist Advisers, in the form of the completed questionnaires, is normally published in full on the NICE website during public consultation, except in circumstances but not limited to where comments are considered voluminous, or publication would be unlawful or inappropriate. Four Specialist Advisor Questionnaires for sacral nerve stimulation for chronic non-obstructive urinary retention were submitted and can be found on the NICE website.

Patient commentators' opinions

NICE's Public Involvement Programme sent 55 questionnaires to 4 NHS trusts for distribution to patients who had the procedure (or their carers). NICE received 21 completed questionnaires.

The patient commentators raised the following issues about the efficacy of the procedure which did not feature in the published evidence or the opinions of specialist advisers, and which the Committee considered to be particularly relevant:

- The patient commentaries reported consistent benefits from the procedure and they described substantial improvements in quality of life.

Issues for consideration by IPAC

Ongoing trials:

- Sacral Neuromodulation for Neurogenic LUT Dysfunction (NCT02165774), randomised, placebo-controlled, double-blind clinical trial, Switzerland, estimated enrolment 60, estimated primary completion date April 2016.
- Time of Effect Onset in Treating Overactive Bladder or Non Obstructive Urinary Retention by Sacral Neuromodulation (NCT02040519), open-label, single group assignment, the Netherlands, estimated enrolment 40, estimated primary completion date December 2014.
- Sacral Neuromodulation With InterStim® Therapy for Intractable Urinary Voiding Dysfunctions (SOUNDS): an Observational Study (NCT02186041), cohort study, France, estimated enrolment 250, estimated primary completion date August 2018.

References

1. Gross C, Habli M, Lindsell C et al. (2010) Sacral neuromodulation for nonobstructive urinary retention: a meta-analysis. Female Pelvic Medicine & Reconstructive Surgery 16: 249–53
2. Jonas U, Fowler CJ, Chancellor MB et al. (2001) Efficacy of sacral nerve stimulation for urinary retention: results 18 months after implantation. Journal of Urology 165: 15–9
3. Datta SN, Chaliha C, Singh A et al. (2008) Sacral neurostimulation for urinary retention: 10-year experience from one UK centre. BJU International 101: 192–6
4. White WM, Dobmeyer-Dittrich C, Klein FA et al. (2008) Sacral nerve stimulation for treatment of refractory urinary retention: long-term efficacy and durability. Urology 71: 71–4
5. Peeters K, Sahai A, De Ridder D et al. (2014) Long-term follow-up of sacral neuromodulation for lower urinary tract dysfunction. BJU International 113: 789–94

Appendix A: Additional papers on sacral nerve stimulation for idiopathic chronic non-obstructive urinary retention

The following table outlines the studies that include more than 20 patients with idiopathic chronic non-obstructive urinary retention, which are considered potentially relevant to the IP overview but were not included in the main data extraction table (table 2). It is by no means an exhaustive list of potentially relevant studies.

Article	Number of patients/ follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
Blandon RE, Gebhart JB, Lightner DJ et al. (2008) Re-operation rates after permanent sacral nerve stimulation for refractory voiding dysfunction in women. BJU International 101: 1119-1123	Case series n=95 (35 with urinary retention)	Response rates were lower in the PNE than in the tined lead (40% vs 67%, p=0.01). The indication was associated with the response rate, with urinary retention having the highest response (71%, p=0.01). For the 55 implanted devices, there were 18 revisions (33%) and 8 explants (15%). The main reasons for revision or explants were loss of efficacy (16/26) and pain at the implant site (6/26).	Mixed indications.
Cardarelli S, D'Elia C, Cerruto MA et al. (2012) Efficacy of sacral neuromodulation on urological diseases: a multicentric research project. Urologia (Treviso) 79: 90-96	Case series n=52 (urinary retention) Follow-up=11 months	In patients treated for UR, we observed a statistically significant reduction in the mean post-voiding residual volume and in the number of self catheterization. This multicenter research project confirmed the midterm safety and effectiveness of sacral neuromodulation in the treatment of refractory overactive bladder syndrome and urinary retention, showing high cure rates and low complication rates.	Studies with longer follow-up are included.
Daniels DH, Powell CR, Braasch MR et al. (2010) Sacral neuromodulation in diabetic patients: success and complications in the treatment of voiding dysfunction. Neurourology & Urodynamics 29: 578-581	Case series n=64 Mean follow-up=29 months	No difference in long-term success rates was seen in diabetic patients when compared with similar, non-diabetic patients. Diabetic patients did, however, have a higher incidence of device explantation due to infection.	Study focuses on patients with diabetes.

Article	Number of patients/ follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
Dasgupta R, Fowler CJ (2004) Urodynamic study of women in urinary retention treated with sacral neuromodulation. Journal of Urology 171: 1161-1164	Case series n=30	This evidence suggests that neuromodulation does not restore voiding in these patients by a direct relaxant effect on the sphincter. The modest increase in detrusor pressure appears to be sufficient to overcome the resistance of the overactive sphincter.	Study focuses on mechanism of action.
Dasgupta R, Wiseman OJ, Kitchen N et al. (2004) Long-term results of sacral neuromodulation for women with urinary retention. BJU International 94: 335-337	Case series n=26 Follow-up=37 months	In young women with retention, for whom there is still no alternative to lifelong self-catheterization, sacral neuromodulation is effective for up to 5 years after implantation. However, there was a significant complication rate, in line with other reports, which may be improved by new technical developments.	Small case series.
Deng DY, Gulati M, Rutman M et al. (2006) Failure of sacral nerve stimulation due to migration of tined lead. Journal of Urology 175: 2182-2185	Case series n=235	Lead migration after placement of the tined lead can occur and thus sacral radiographs should be routinely used. This complication can be easily resolved without significant morbidity to the patient	Mixed indications.
De Ridder D, Ost D, Bruyninckx F (2007) The presence of Fowler's syndrome predicts successful long-term outcome of sacral nerve stimulation in women with urinary retention. European Urology 51: 229-233	Case series n=62 Follow-up=43 months	Twenty-eight patients failed: 9 with Fowler's syndromes, 19 without (p=0.04). Kaplan-Meier analysis showed that patients with Fowler's syndrome benefitted significantly longer from SNS (log-rank test, p=0.005)	More recent studies are included.
Elneil S, Abtahi B, Helal M et al. (2012). Optimizing the duration of assessment of stage-1 sacral neuromodulation in nonobstructive chronic urinary retention. Neuromodulation 17: 66-70	Case series n=24 Follow-up=31 days	Normal bladder sensation was restored on the same day as switching on the battery after stage-1 in seven patients (29.2%), while in 17 patients it occurred between day 2-31 (mean: nine days). Similarly, the mean onset of voiding was also nine days (range: 2-31 days). After day 15, 21% of patients voided.	larger studies with longer follow-up are included.
Everaert K, De Ridder D, Baert, L et al. (2000) Patient satisfaction and complications following sacral nerve stimulation for urinary retention, urge incontinence and perineal pain: a multicenter evaluation. International Urogynecology Journal 11: 231-235	Case series n=53 (38 dysuria or retention) Mean follow-up=24 months	During the first few months, 45 (85%) of the 53 patients had an objective response. Eight late failures occurred, with a mean failure delay of 9 +/- 5 months.	Small case series with mixed indications.

Article	Number of patients/ follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
Everaert K, De Muynck M, Rimbaut S et al. (2003) Urinary retention after hysterectomy for benign disease: extended diagnostic evaluation and treatment with sacral nerve stimulation. BJU International 91: 497-501	Case series n=15	Uroflowmetry at the last follow-up showed a mean (sd) maximum urinary flow rate of 22 (18) mL/s (not significantly different from during trial stimulation) with residual urine of 50-100 ml in 2 and 200-400 ml in 3 patients. Intermittent catheterization was needed in 4 patients	Small case series, which is included in the systematic review (Gross et al., 2010).
Goh M, Diokno AC (2007) Sacral neuromodulation for nonobstructive urinary retention--is success predictable? Journal of Urology 178: 197-199	Case series n=29	Of the 18 patients who were able to void 12 (67%) underwent successful permanent implantation. However, voiding improved after test stimulation in only 2 of the 11 patients (18%) who had been unable to void. This difference was statistically significant (p=0.02) and suggests that pre-implantation ability to void can predict success of test stimulation.	Small case series.
Guralnick ML, Benouni S, O'Connor RC et al. (2007) Characteristics of infections in patients undergoing staged implantation for sacral nerve stimulation. Urology 69: 1073-1076	Case series n=76	Lead infection occurred in 9 of 76 patients (12%). 45 patients had an implantable pulse generator implanted, and 5 infections occurred (11%). Apart from known risk factors for surgical wound infections, the only variable we could identify that might increase the risk for infection is a longer operative time for Stage 2.	Mixed indications.
Haraway AM, Clemens JQ, He C et al. (2013) Differences in sacral neuromodulation device infection rates based on preoperative antibiotic selection. International Urogynecology Journal and Pelvic Floor Dysfunction 24: 2081-2085	Case series n=24 (urinary retention)	Preoperative antibiotic selection was a significant factor in preventing subsequent infection and explantation following SNM placement.	Study focuses on use of preoperative antibiotics.
Hassouna MM, Elkelini MS (2007) Early versus late treatment of voiding dysfunction with pelvic neuromodulation. Canadian Urological Association Journal 1: 106-110	Case series n=42	Patients who were delayed more than 6 months in receiving the neurostimulator implant showed a worse response than did patients who had the device implanted soon after PNE. This indicates the possibility of disease progression, which may limit the response to sacral neuromodulation	Small case series, focusing on the timing of treatment.

Article	Number of patients/ follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
Herbison GP, Arnold EP (2009) Sacral neuromodulation with implanted devices for urinary storage and voiding dysfunction in adults. Cochrane Database of Systematic Reviews (2) CD004202	Systematic review	It was unclear whether some reports included patients who also appeared in other reports, so no data were pooled. In spite of this, it seems clear that continuous stimulation offers benefits for carefully selected people with overactive bladder syndrome and for those with urinary retention but no structural obstruction. Many of the implants did not work and many required revision operations. Many questions remain about patient selection and the best way to use these devices	Only includes 1 RCT on urinary retention, which is already included in table 2.
Lenis AT, Gill BC, Carmel ME et al. (2013) Patterns of hardware related electrode failures in sacral nerve stimulation devices. Journal of Urology 190: 175–9	Case series n=565	Abnormal electrical impedance occurred in approximately 13% of cases permanently implanted. Short circuits presented earlier and often required surgical intervention. Open circuits presented later and may have potentially been secondary to microfractures that accumulate with time at the sacral plate, resulting in later presentation. Almost a third of patients with abnormal electrical impedance associated with clinical inefficacy were treated conservatively, primarily with reprogramming.	Study focuses on details of device failure.
Leong RK, de Wachter SG, Nieman FH et al. (2011) PNE versus 1st stage tined lead procedure: a direct comparison to select the most sensitive test method to identify patients suitable for sacral neuromodulation therapy. Neurourology & Urodynamics 30: 1249-1252	Case series n=100 (31 urinary retention) Mean follow-up=2 years	This study suggests that first-stage tined-lead placement test may be a more sensitive screening method than PNE to identify patients eligible for SNM therapy, warranting randomized trials.	Study focuses on the use of a tined lead as a screening tool.
Leong RK, Marcelissen TA, Nieman FH et al. (2011) Satisfaction and patient experience with sacral neuromodulation: results of a single center sample survey. Journal of Urology 185: 588-592	Case series n=207 (57 nonobstructive urinary retention)	Overall satisfaction with sacral neuromodulation was high at 90%. No correlations were found between the satisfaction rate, and pretreatment age, gender, complaint type, sexual dysfunction or therapy duration.	Mixed indications.

Article	Number of patients/ follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
Peters KM, Feber KM, Bennett RC (2005) Sacral versus pudendal nerve stimulation for voiding dysfunction: a prospective, single-blinded, randomized, crossover trial. Neurourology & Urodynamics 24: 643-647	RCT n=30 (3 urinary retention)	Overall reduction in symptoms was 63% for pudendal nerve stimulation and 46% for sacral nerve stimulation (p=0.02). On a 7-point scale from markedly worse to markedly better, the pudendal lead was superior to sacral for pelvic pain (p=0.024), urgency (p=0.005), frequency (p=0.007), and bowel function (p=0.049). Complications were minimal.	Only 3 patients had urinary retention.
Pham K, Guralnick ML, O'Connor RC (2008) Unilateral versus bilateral stage I neuromodulator lead placement for the treatment of refractory voiding dysfunction. Neurourology & Urodynamics 27: 779-781	Case series n=124 (27 urinary retention)	44% (55/124) of patients underwent unilateral stage I lead placement and 69 (56%) received bilateral S3 leads. Successful stage I trials were reported in 32/55 (58%) and 53/69 (76%) of unilateral and bilateral cohorts, respectively (p=0.03). 5 wound infections were reported - 2 (3.6%) following unilateral and 3 (4.3%) after bilateral stage I lead placement. No other complications were encountered.	Mixed indications.
Saber-Khalaf M, Abtahi B, Gonzales G et al. (2015) Sacral Neuromodulation Outcomes in Male Patients with Chronic Urinary Retention. Neuromodulation DOI: 10.1111/ner.12268	Case series n=21 Follow-up=34 months	Stage-1 SNM was successful in 66.7% of male patients with CUR. Once stage-2 was performed, successful voiding was maintained until the battery needed to be replaced. SNM success was better in men under a median age of 43 years. Further studies are encouraged to study this group of patients.	Small case series.
Scheepens WA, Jongen MM, Nieman FH et al. (2002) Predictive factors for sacral neuromodulation in chronic lower urinary tract dysfunction. Urology 60: 598-602	Case series n=211	Intervertebral disk prolapse, duration of complaints, neurogenic bladder dysfunction, and urge incontinence were found to be significant predictive factors.	Mixed indications. Study focuses on clinical parameters that can enhance the prediction of PNE success.

Article	Number of patients/ follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
Scheepens WA, de Bie RA, Weil EH et al. (2002) Unilateral versus bilateral sacral neuromodulation in patients with chronic voiding dysfunction. Journal of Urology 168: 2046-2050	RCT (bilateral vs unilateral stimulation) n=33 Follow-up=10 days	Bilateral is in general not superior to unilateral sacral neuromodulation. However, in some individuals bilateral stimulation may be more effective in relieving symptoms. Therefore, if unilateral percutaneous nerve evaluation fails, a bilateral test should be considered.	Study is included in the systematic review (Gross et al., 2010).
Seif C, Eckermann J, Bross S et al. (2004) Findings with Bilateral Sacral Neurostimulation: Sixty-two PNE-Tests in Patients with Neurogenic and Idiopathic Bladder Dysfunctions. Neuromodulation 7: 141-145	Case series n=36 (urinary retention)	The PNE test was successful in 32 patients (51.6%). Of these, 27 suffered from neurogenic bladder dysfunction; in five cases the cause was idiopathic.	Studies with longer follow-up are included.
Sharifiaghdas F, Mirzaei M, Ahadi B (2014) Percutaneous nerve evaluation (PNE) for treatment of non-obstructive urinary retention: urodynamic changes, placebo effects, and response rates. Urology Journal 11: 1301-1307	Case series n=45 Follow-up=10 days	28 (62.2%) demonstrated greater than 50% improvement in the urinary symptoms. Patients with complete non obstructive urinary retention were good responders to PNE. The placebo effect in sacral nerve stimulation was negligible.	Small case series with short follow-up.
Shih C, Miller JL, Fialkow M et al. (2013) Reoperation after sacral neuromodulation therapy: A single-institution experience. Female Pelvic Medicine and Reconstructive Surgery 19:175– 8	Case series n=142 (30 with urinary retention)	55 (38%) patients required reoperation, for either revision or explantation of the device. Revisions were performed in 30 (21%) patients, most commonly for mechanical failure of device, battery end-of-service, and pain, either at the site of the implanted pulse generator or with stimulation. Of the 30 patients who underwent revision, 14 had successful results, 6 had persistent symptoms, and 10 progressed to eventual explantation. The overall explantation rate was 25% (35/142 patients), and the average time to removal was 44 months.	Mixed indications.
Siegel SW, Catanzaro F, Dijkema HE et al. (2000) Long-term results of a multicenter study on sacral nerve stimulation for treatment of urinary urge incontinence, urgency-frequency, and retention. Urology 56 (6:Suppl 1) Suppl-91	Case series n=42 (urinary retention) Follow-up=1.5–3 years	After 1. 5 years, 70% of 42 retention patients showed greater than 50% reduction in catheter volume per catheterization.	More recent or larger studies are included. Study is included in the systematic review (Gross et al., 2010).

Article	Number of patients/ follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
Spinelli M, Weil E, Ostardo E et al. (2005) New tined lead electrode in sacral neuromodulation: experience from a multicentre European study. World Journal of Urology 23: 225-229	Case series n=127 (50 with urinary retention)	Screening with the tined lead was considered successful by the physicians in 77% of patients (n=72). The outcome of this study supports the use of the tined lead electrode as a screening tool in SNS therapy.	Study focuses on the use of the tined lead as a screening tool.
Spinelli M, Bertapelle P, Cappellano F et al. (2001) Chronic sacral neuromodulation in patients with lower urinary tract symptoms: Results from a national register. Journal of Urology.166: 541-545	Case series (national register) n=55 (urinary retention)	For idiopathic retention average residual volume decreased from 277 to 108 cc (median 287 and 80, respectively), and 50% of patients stopped catheterization and another 13% catheterized once daily at 1-year after implantation. With neurogenic voiding disturbances, the results fluctuated with time from a minimum of 33% to a maximum 66% of patients who did not catheterize at 6-month follow up and 12 months after implantation, respectively.	More recent or larger studies are included. Study is included in the systematic review (Gross et al., 2010).
Swinn MJ, Kitchen ND, Goodwin RJ et al. (2000) Sacral neuromodulation for women with Fowler's syndrome. European Urology 38: 439–43	Case series n=38	The overall success rate in this group was 68%.12 of the patients subsequently underwent permanent implantation of a sacral nerve stimulator, and all of them have experienced a return of voiding. However, in 2 patients, there is a persisting need for self-catheterization. There is, however, a high reoperation rate.	Length of follow-up is unclear.
Van Kerrebroeck PE, van Voskuilen AC, Heesakkers JP et al. (2007) Results of sacral neuromodulation therapy for urinary voiding dysfunction: outcomes of a prospective, worldwide clinical study. Journal of Urology 178: 2029–34	Case series n=31 (urinary retention)	At 5 years after implantation 71% of patients with retention had successful outcomes.	Small case series, which is included in the systematic review (Gross et al., 2010).
van Voskuilen AC, Oerlemans DJ, Weil EH et al. (2006) Long term results of neuromodulation by sacral nerve stimulation for lower urinary tract symptoms: a retrospective single center study. European Urology 49: 366-372	Case series n=42 (urinary retention) Mean follow-up=64 months	SNS gives lasting benefit in patients with refractory symptoms of overactive bladder and non-obstructive urinary retention. The differences in outcomes and incidence of reoperation can be attributed to the learning curve and technical and surgical improvements in the application of SNS	An earlier article from the same study is included in the systematic review (Gross et al., 2010)

Article	Number of patients/ follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
Vaarala MH, Tammela TL, Perttila I et al. (2011) Sacral neuromodulation in urological indications: the Finnish experience. Scandinavian Journal of Urology & Nephrology 45: 46-51	Case series n=180 (54 urinary retention) Mean follow-up=41 months	Significant improvement after implantation was noted in the mean urinated volumes and number of daily urinations, as well as in the number of catheterizations in urgency-frequency syndrome and urinary retention, respectively.	Mixed indications.
White WM, Mobley JD III, Doggweiler R et al. (2009) Incidence and predictors of complications with sacral neuromodulation. Urology 73: 731-735	Case series n=37 (urinary retention)	The significant predictors of adverse events included a history of trauma ($p<0.001$), a change in body mass index class ($p<0.001$), enrolment in a pain clinic ($p=0.008$), the duration of follow-up ($p=0.002$), and a history of adverse events ($p<0.001$). The results of our study have shown that SNS is an effective treatment for patients with intractable voiding dysfunction. Complications are not uncommon but can be minimized with better patient selection.	Mixed indications.

Appendix B: Related NICE guidance for sacral nerve stimulation for idiopathic chronic non-obstructive urinary retention

Guidance	Recommendations
Interventional procedures	**Sacral nerve stimulation for urge incontinence and urgency-frequency. NICE interventional procedure guidance 64 (2004).** 1.1 Current evidence on the safety and efficacy of sacral nerve stimulation for urge incontinence and urgency-frequency appears adequate to support the use of this procedure provided that the normal arrangements are in place for consent, audit and clinical governance. 1.2 Patient selection is important. The diagnosis should be defined as clearly as possible and the procedure limited to patients who have not responded to conservative treatments such as lifestyle modifications, behavioural techniques and drug therapy. Patients should be selected on the basis of their response to peripheral nerve evaluation. **Sacral nerve stimulation for faecal incontinence. NICE interventional procedure guidance 99 (2004).** 1.1 Current evidence on the safety and efficacy of sacral nerve stimulation for faecal incontinence appears adequate to support the use of this procedure, provided that the normal arrangements are in place for consent, audit and clinical governance. 1.2 The procedure should only be performed in specialist units by clinicians with a particular interest in the assessment and treatment of faecal incontinence.
Clinical guidelines	**Lower urinary tract symptoms: The management of lower urinary tract symptoms in men. NICE clinical guideline 97 (2010).** **1.7 Treating urinary retention** 1.7.1 Immediately catheterise men with acute retention. 1.7.2 Offer an alpha blocker to men for managing acute urinary retention before removal of the catheter. 1.7.3 Consider offering self- or carer-administered intermittent

	urethral catheterisation before offering indwelling catheterisation for men with chronic urinary retention. 1.7.4 Carry out a serum creatinine test and imaging of the upper urinary tract in men with chronic urinary retention (residual volume greater than 1 litre or presence of a palpable/percussable bladder). 1.7.5 Catheterise men who have impaired renal function or hydronephrosis secondary to chronic urinary retention. 1.7.6 Consider offering intermittent or indwelling catheterisation before offering surgery in men with chronic urinary retention. 1.7.7 Consider offering surgery on the bladder outlet without prior catheterisation to men who have chronic urinary retention and other bothersome LUTS but no impairment of renal function or upper renal tract abnormality. 1.7.8 Consider offering intermittent self- or carer-administered catheterisation instead of surgery in men with chronic retention who you suspect have markedly impaired bladder function. 1.7.9 Continue or start long-term catheterisation in men with chronic retention for whom surgery is unsuitable. 1.7.10 Provide active surveillance (post void residual volume measurement, upper tract imaging and serum creatinine testing) to men with non-bothersome LUTS secondary to chronic retention who have not had their bladder drained. **Urinary incontinence in neurological disease: Management of lower urinary tract dysfunction in neurological disease. NICE clinical guideline 148 (2012).** 1.5 Treatment to improve bladder emptying Alpha-blockers 1.5.1 Do not offer alpha-blockers to people as a treatment for bladder emptying problems caused by neurological disease. 1.6 Management with catheter valves 1.6.1 In people for whom it is appropriate a catheter valve may be used as an alternative to a drainage bag. 1.6.2 To ensure that a catheter valve is appropriate, take into consideration the person's preference, family member and carer support, manual dexterity, cognitive ability, and lower urinary tract function when offering a catheter valve as an alternative to continuous drainage into a bag. 1.6.3 Consider the need for continuing upper urinary tract surveillance in people who have impaired bladder storage (for example, due to reduced bladder compliance). 1.7 Management with ileal conduit diversion

	1.7.1 For people with neurogenic lower urinary tract dysfunction who have intractable, major problems with urinary tract management, such as incontinence or renal deterioration: • consider ileal conduit diversion (urostomy) and • discuss with the person the option of simultaneous cystectomy as prophylaxis against pyocystis. 1.10 Potential complications: providing information and initial management Renal impairment 1.10.1 Discuss with the person and/or their family members and carers the increased risk of renal complications (such as kidney stones, hydronephrosis and scarring) in people with neurogenic urinary tract dysfunction (in particular those with spina bifida or spinal cord injury). Tell them the symptoms to look out for (such as loin pain, urinary tract infection and haematuria) and when to see a healthcare professional. 1.10.2 When discussing treatment options, tell the person that indwelling urethral catheters may be associated with higher risks of renal complications (such as kidney stones and scarring) than other forms of bladder management (such as intermittent self catheterisation). 1.10.3 Use renal imaging to investigate symptoms that suggest upper urinary tract disease. Bladder stones 1.10.4 Discuss with the person and/or their family members and carers the increased risk of bladder stones in people with neurogenic lower urinary tract dysfunction. Tell them the symptoms to look out for that mean they should see a healthcare professional (for example, recurrent infection, recurrent catheter blockages or haematuria). 1.10.5 Discuss with the person and/or their family members and carers that indwelling catheters (urethral and suprapubic) are associated with a higher incidence of bladder stones compared with other forms of bladder management. Tell them the symptoms to look out for that mean they should see a healthcare professional (for example, recurrent infection, recurrent catheter blockages or haematuria). 1.10.6 Refer people with symptoms that suggest the presence of bladder stones (for example, recurrent catheter blockages, recurrent urinary tract infection or haematuria) for cystoscopy. Bladder cancer 1.10.7 Discuss with the person and/or family members and carers that there may be an increased risk of bladder cancer in

	people with neurogenic lower urinary tract dysfunction, in particular those with a long history of neurogenic lower urinary tract dysfunction and complicating factors, such as recurrent urinary tract infections. Tell them the symptoms to look out for (especially haematuria) that mean they should see a healthcare professional. 1.10.8 Arrange urgent (within 2 weeks) investigation with urinary tract imaging and cystoscopy for people with: • visible haematuria or • increased frequency of urinary tract infections or • other unexplained lower urinary tract symptoms. **Urinary incontinence: The management of urinary incontinence in women. NICE clinical guideline 171 (2013).** Catheters 1.6.2 Bladder catheterisation (intermittent or indwelling urethral or suprapubic) should be considered for women in whom persistent urinary retention is causing incontinence, symptomatic infections, or renal dysfunction, and in whom this cannot otherwise be corrected. Healthcare professionals should be aware, and explain to women, that the use of indwelling catheters in urgency UI may not result in continence. [2006] Intermittent urethral catheters 1.6.3 Offer intermittent urethral catheterisation to women with urinary retention who can be taught to self-catheterise or who have a carer who can perform the technique. [2006] Indwelling urethral catheters 1.6.4 Give careful consideration to the impact of long-term indwelling urethral catheterisation. Discuss the practicalities, benefits and risks with the patient or, if appropriate, her carer. Indications for the use of long-term indwelling urethral catheters for women with UI include: • chronic urinary retention in women who are unable to manage intermittent self-catheterisation • skin wounds, pressure ulcers or irritations that are being contaminated by urine • distress or disruption caused by bed and clothing changes • where a woman expresses a preference for this form of management. [2006] Indwelling suprapubic catheters

	1.6.5 Indwelling suprapubic catheters should be considered as an alternative to long-term urethral catheters. Be aware, and explain to women, that they may be associated with lower rates of symptomatic UTI, 'bypassing', and urethral complications than indwelling urethral catheters. [2006] Percutaneous sacral nerve stimulation 1.9.10 Offer percutaneous sacral nerve stimulation to women after MDT review if: • their OAB has not responded to conservative management including drugs, and • they are unable to perform clean intermittent catheterisation. [new 2013] 1.9.11 Consider percutaneous sacral nerve stimulation after MDT review if a woman's OAB has not responded to conservative management (including drugs) and botulinum toxin A[7]. [new 2013] 1.9.12 Discuss the long-term implications of percutaneous sacral nerve stimulation with women including: • the need for test stimulation and probability of the test's success • the risk of failure • the long-term commitment • the need for surgical revision • the adverse effects. [new 2013] 1.9.13 Tell women how to self-refer for prompt specialist review if symptoms return following a percutaneous sacral nerve stimulation procedure. [new 2013]

Appendix C: Literature search for sacral nerve stimulation for idiopathic chronic non-obstructive urinary retention

Databases	Date searched	Version/files
Cochrane Database of Systematic Reviews – CDSR (Cochrane Library)	27/02/2015	Issue 2 of 12, February 2015
Database of Abstracts of Reviews of Effects – DARE (Cochrane Library)	27/02/2015	Issue 1 of 4, January 2015
HTA database (Cochrane Library)	27/02/2015	Issue 1 of 4, January 2015
Cochrane Central Database of Controlled Trials – CENTRAL (Cochrane Library)	27/02/2015	Issue 1 of 12, January 2015
MEDLINE (Ovid)	27/02/2015	1946 to February Week 4 2015
MEDLINE In-Process (Ovid)	27/02/2015	February 26, 2015
EMBASE (Ovid)	27/02/2015	1974 to 2015 Week 08
PubMed	27/02/2015	n/a
BLIC	27/02/2015	n/a

Trial sources searched on 28 01 2015

- National Institute for Health Research Clinical Research Network Coordinating Centre (NIHR CRN CC) Portfolio Database
- Current Controlled Trials metaRegister of Controlled Trials – mRCT
- Clinicaltrials.gov

Websites searched on 28 01 2015

- National Institute for Health and Care Excellence (NICE)
- NHS England
- Food and Drug Administration (FDA) - MAUDE database
- French Health Authority (FHA)
- Australian Safety and Efficacy Register of New Interventional Procedures – Surgical (ASERNIP – S)
- Australia and New Zealand Horizon Scanning Network (ANZHSN)
- Conference websites <<add details>>
- General internet search

The following search strategy was used to identify papers in MEDLINE. A similar strategy was used to identify papers in other databases.

1	Electrical Stimulation Therapy/
2	((sacral* or s3) adj4 (stimul* or modulat*)).tw.
3	((sacral or s3) adj4 ((nerve* or neural) adj4 stimul*)).tw.
4	((sacral or s3) adj4 (electrostimul* or "electrical stimul*")).tw.
5	Neuromodulat*.tw.
6	Neurostimulat*.tw.
7	Peripheral nerve/ and Electrical stimulation/
8	(peripheral adj4 nerve* adj4 (stimulat* or modulat* or electrostimul*)).tw.
9	SNS.tw.
10	Interstim.tw.
11	or/1-10
12	Urinary retention/
13	((non-obstruct* or nonobstruct* or "non obstruct*") adj4 ((urin* adj4 (retention* or retain*)) or ischuria*)).tw.
14	(Fowler* adj4 syndrome*).tw.
15	(Neuropathic* adj4 bladder* adj4 dysfunction*).tw.
16	(Neurogenic* adj4 bladder*).tw.
17	(voiding adj4 (dysfunction* or difficult* or problem* or disorder*)).tw.
18	or/12-17
19	11 and 18
20	animals/ not humans/
21	19 not 20
22	limit 21 to english language