

## REVIEW

# Efficacy of sacral neuromodulation and percutaneous tibial nerve stimulation in the treatment of chronic nonobstructive urinary retention: A systematic review

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## Abstract

**Aim:** The aim of this systematic review is to provide an updated report on the efficacy and complications of sacral neuromodulation (SNM) and percutaneous tibial nerve stimulation (PTNS) in the treatment of chronic non-obstructive urinary retention (CNOUR), with a focus on the contemporary technique of SNM utilizing the percutaneous placement of tined leads.

**Methods:** This systematic review was conducted with the use of PRISMA guidelines and registered with PROSPERO (CRD42020208052). A systematic literature search was conducted in Embase, PubMed, and Cochrane databases. Inclusion criteria include English language and human participants. Exclusion criteria include SNM studies involving less than 10 CNOUR patients, studies containing data obtained using open, surgical implantation of nontined leads, and studies that only reported the test phase success rate with no long-term efficacy data. The risk of bias assessment was conducted using the National Institutes of Health study quality assessment tool.

**Results:** A total of 16 papers studies were included (11 SNM and 5 PTNS) in this review. The success rate for SNM ranges between 42.5% and 100% (median = 79.2%) for the test stimulation phase and 65.5%–100% (median = 89.1%) in the long term. Most SNM studies reported revision and explantation rates of lesser than 20%. The success rate was much lower for PTNS, in the 50%–60% range and complications were minimal.

**Conclusion:** SNM using the contemporary percutaneous tined lead implantation technique appears to be an effective treatment for CNOUR and is durable in the long term. Compared to SNM, PTNS appears less efficacious with less evidence supporting its use in CNOUR. Further prospective studies are required to define the role of PTNS in the treatment of CNOUR.

## KEYWORDS

chronic nonobstructive urinary retention, hypocontractile bladder, percutaneous tibial nerve stimulation, sacral neuromodulation, voiding dysfunction

**Abbreviations:** CNOUR, chronic nonobstructive urinary retention; C-D, Clavien–Dindo; ISC, intermittent catheterization; NIH, National Institutes of Health; PNE, percutaneous nerve evaluation; PTNS, percutaneous tibial nerve stimulation; PVR, postvoid residual; SNM, sacral neuromodulation.

## 1 | INTRODUCTION

Chronic nonobstructive urinary retention (CNOUR) is the inability to empty the bladder in the absence of a physical obstruction.<sup>1</sup> It is primarily a result of a hypocontractile or acontractile bladder, leading to bladder dysfunction.<sup>2</sup> The causes of bladder dysfunction are often multi-factorial in origin, and they include myogenic, neurogenic, or psychogenic causes.<sup>2</sup> Neurogenic causes can result from diseases such as multiple sclerosis, spinal cord injury, and Parkinson's disease.

Chronic urinary retention is associated with medical complications such as renal damage and overflow incontinence<sup>2,3</sup> and can also have a negative impact on the psychological well-being of the affected individual.<sup>4</sup> Unfortunately, management of CNOUR is challenging because there is no effective medical management available. Traditionally, these patients are managed symptomatically with intermittent self-catheterization (ISC) or permanent catheterization.<sup>5</sup> However, ISC is strongly associated with impairment of daily activities and psychological distress such as embarrassment and low self-esteem.<sup>5</sup>

The introduction of sacral neuromodulation (SNM) by Tanagho and Schmidt<sup>6</sup> in 1981 has provided CNOUR patients with a permanent treatment option. Over the years, there have been major advances in this surgical procedure such as the development of the two-stage implantation technique.<sup>7</sup> More recently, a minimally invasive approach to placement of the permanent tined leads into the sacral foramen has been described by Spinelli et al.<sup>8</sup> This percutaneous technique has eliminated the need for deep incision and use of general anesthetics, allowing for more accurate lead placement.<sup>8</sup> Moreover, the design of the tined lead also helps to prevent dislodgement of the electrodes. This updated systematic review aims to determine the short and long-term efficacy of SNM in the treatment of CNOUR using the newer percutaneous technique for definitive tined lead implantation.

Percutaneous tibial nerve stimulation (PTNS) is another type of neuromodulatory therapy available for lower urinary tract dysfunction. In comparison to SNM, PTNS is less invasive and does not require device implantation which may be incompatible with magnetic resonance imaging (MRI) scans. There are well-established data for its use in the treatment of overactive bladder (OAB) and it has been approved by multiple countries including the United States, United Kingdom, and Australia to do so.<sup>9,10</sup> Despite so, the use of PTNS in CNOUR is less established. Therefore, this systematic review also aims to determine the efficacy of PTNS in

CNOUR and to qualitatively compare its efficacy to that of SNM.

## 2 | METHODS

This systematic review was conducted with the use of the PRISMA guidelines and the protocol was registered with PROSPERO (<https://www.crd.york.ac.uk/prospere>; CRD42 020208052). A systematic search of the literature using Embase, PubMed, and Cochrane databases was performed in August 2020 to identify studies evaluating the treatment of CNOUR using SNM and PTNS (see Supporting Information 1 for search strategies).

The study population includes CNOUR patients who were treated with SNM or PTNS. Inclusion criteria include English language articles, human participants and, studies with full texts available. Exclusion criteria was only applied to SNM, and not PTNS studies due to the limited number of studies available for the latter. This includes studies involving less than 10 CNOUR patients, studies that included results obtained using open, surgical implantation of nontined leads and studies which only reported the test phase success rate. A cut-off of 10 patients was chosen in an attempt to improve the validity of this review.

The systematic search was performed independently by two authors. The initial search identified 630 articles. All the titles and abstracts were screened and articles that did not meet the initial inclusion criteria were excluded. A total of 50 full-text articles were retrieved and further assessed for eligibility to be included in the systematic review. An additional five papers were identified from references of these articles, but none met the criteria to be included in the final data analysis.

Data extraction was performed by two independent authors, discrepancies were discussed to reach a consensus. Any unresolvable discrepancy was discussed with a third author to reach a consensus. The following aspects were evaluated for each paper: study design, follow-up duration, mean patients age, pre- and post-SNM outcome measures results, Stage 1 success rate, long-term success rate, and complication rates. A qualitative analysis was performed to summarize the findings in the literature. Quantitative analysis was unable to be performed due to heterogeneity in patients' characteristics, outcome measures, the definition of success, and follow-up duration. The risk of bias of assessment was conducted using the National Institutes of Health (NIH) study quality assessment tool<sup>11</sup> and plotted using the Robvis tool<sup>12</sup> (see Supporting Information 2).

### 3 | RESULTS

A total of 16 out of the 630 articles identified in the initial search were included in the final data analysis. All of them were pre-post studies (nine prospective and seven retrospective) published between the years of 2001–2020. Results of the search strategy were summarized in Figure 1.

#### 3.1 | Sacral neuromodulation

##### 3.1.1 | Studies characteristics

Eleven SNM studies published between the years of 2005–2020 were included in our analysis.<sup>7,13–22</sup> These include four prospective and seven retrospective pre-post

studies. There were five mixed cohort studies which also included patients suffering from one or more of the following: OAB, urinary urge incontinence, urgency-frequency syndrome, and interstitial cystitis.<sup>7,15,19,20,22</sup> Among the 11 papers, there were 2 papers published by the same primary author, but 1 year apart and it was not possible to determine the extent of population overlap between these two studies.<sup>13,14</sup> In total, 450 CNOUR patients were identified. All of them were adult patients with a mean age ranging between 32.5 and 51 years old. The causes of CNOUR were largely neurogenic in origins such as spinal cord and lumbosacral injury, cerebrovascular events, pelvic floor injury, and postsurgical denervation. Three studies reported a mean duration of symptoms ranging between 3.2 and 6 years and one study reported at least 6 months duration of symptoms. Conservative treatments that were attempted before SNM

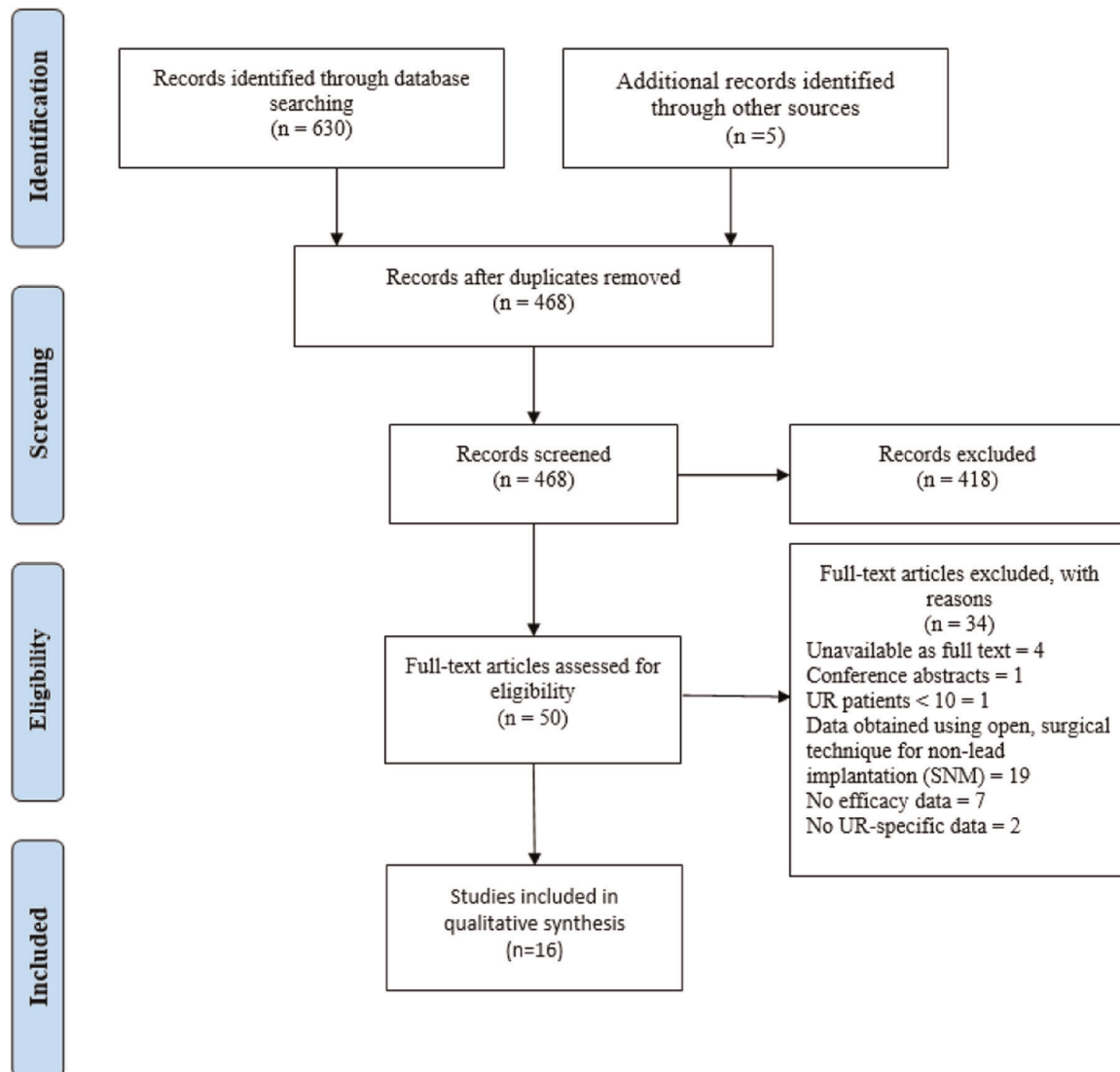


FIGURE 1 PRISMA flow chart. UR, urinary retention

include pelvic floor rehabilitation, bladder biofeedback, electrotherapy, alpha blockers, and sympathomimetics. ISC was used by most patients for symptomatic management.

### 3.1.2 | Surgical technique and outcome measures

Most SNM studies only included patients who underwent the two-stage implantation technique. However, three of the included studies also involved patients who had been tested with percutaneous nerve evaluation (PNE).<sup>7,15,23</sup> Despite having different test stimulation techniques, all the patients were percutaneously implanted with the permanent tined leads. Outcomes at the end of each phase, (test stimulation and implantable pulse generator [IPG] implantation) were determined using voiding symptoms parameters, and/or urodynamic test results. Success rates that were not exclusive to CNOUR patients were indicated in the results table (Table 1).

### 3.1.3 | Efficacy—test stimulation outcomes

The definition for test-stimulation success varied considerably across all the 11 studies. Definitions included: (1) at least 50% improvement in relevant urinary symptoms or voiding diary parameters; (2) restoration of bladder sensation; and (3) restoration of spontaneous voiding with postvoid residual (PVR) volume less than 100 ml at the end of the test phase. The rate of success for CNOUR patients ranged from 42.5% to 100%, with a median of 79.2% (Table 1). The success rate of PNE in CNOUR patients could not be determined as they were all reported as mixed cohort results. Two urodynamic studies, both published by Lombardi et al.<sup>13,14</sup> reported a mean 56.4% increase in patients who were able to void at the end of the first stage SNM. There was also a significant improvement ( $p < 0.01$ ) in all other voiding phase parameters such as PdetQmax, mean maximum flow rate, and mean PVR volume.

### 3.1.4 | Efficacy—long-term outcome

Overall, there were six studies that reported long-term follow-up data for CNOUR patients with a mean success rate of 65.5%–100% at a median follow-up time of 42 months.<sup>13–15,17,18,21</sup> The consensus for long-term success across the studies was sustained improvement in symptoms at the end of a follow-up period. All the studies reported improvement in at least one of the outcome

measures mentioned above. Van Voskuilen et al.<sup>15</sup> reported that 60% of its patients became catheter free at a mean follow-up period of 15.5 months. A similar finding was reported by Mehmood et al.<sup>17</sup> which stated that almost all their patients could eliminate ISC ( $n = 27$ ) and that 70.8% achieved spontaneous voiding. Catheterization frequency was the most reported parameter with five studies reporting a 59.6%–77.9% reduction in mean number of catheterization per day. Meanwhile, Denzinger<sup>16</sup> and Mehmood et al.<sup>17</sup> reported a 93% and 61% reduction in mean PVR volume, respectively (Table 2).

### 3.1.5 | Safety and complications

There were no life-threatening complications reported by any of the studies. The highest grade of complication reported according to the Clavien–Dindo (CD) classification was Grade III. The reported surgical revision rate ranged from 9.6% to 41.6% with the most common cause being IPG site pain, followed by IPG site infection and implant/lead migration. The rate of explantation ranged from 1.1% to 16.6% with a loss of efficacy being the most common cause (overall rate of 6.5%–12.8%). Other common causes were repeated need for MRI scan, IPG site infection and pain. Complications that could be treated conservatively (<CD-III) were mainly related to discomfort, infection, and pelvic symptoms (Table 3). Although the mixed cohort studies reported their efficacy results separately, all of them reported the complication rates as a whole and therefore rates above do not pertain to just CNOUR patients.

## 3.2 | Percutaneous tibial nerve stimulation

### 3.2.1 | Studies characteristics

A total of five PTNS studies (four adults and one pediatrics) published between the year of 2001–2005 were included in our analysis. Four studies involved adult population<sup>23–26</sup> and one study involved pediatric population.<sup>27</sup> There were at least 10 participants in all the studies except for the pediatric study which only had 7. All four of the adult papers were published by the same senior author, H. Bemelmans and may include overlapping patients. Two of the papers by Vandoninck et al.<sup>23,24</sup> used the exact same cohort of patients, with one containing additional urodynamic data. They will be referred to as a single study in this review. The other two papers on the adult population

TABLE 1 Study characteristics and treatment success rates of studies using sacral neuromodulation for the treatment of chronic nonobstructive urinary retention (CNOUR)

First author (publication year)	Type of pre-post study	Total number of patients; number of CNOUR patients	Age <sup>a</sup> (years)	Duration of follow-up <sup>a</sup> (months)	Type of test stimulation	Test stimulation success rate (%)	Long-term success rate (time at follow-up)
Spinelli (2005)	Prospective	127; 50	51	13.8	Mixed PNE and first staged	74% <sup>b</sup>	–
Lombardi (2017) <sup>c</sup>	Retrospective	77	40.1 <sup>d</sup>	55	First stage	100%	65.5% (42 months)
Lombardi (2014) <sup>c</sup>	Retrospective	87	38.2 <sup>d</sup>	50	First stage	42.5%	88.2% (60 months)
Van Voskuilen (2006)	Prospective	49; 10	50.5	15.5	Mixed PNE and first stage	100%	90% (last follow-up)
Denzinger (2011)	Prospective	12	51 (Median)	12 (Median)	First stage	90%	–
Mehmood (2007)	Retrospective	27	32.5	68.4	First stage	88.8%	70.8% (67 months)
Saber-Khalaf (2015)	Retrospective	21	42	34	First stage	66.7%	100% (24 months)
Marcelissen (2010)	Retrospective	64;14	49	53	Mixed PNE and first stage	69.6%	64% <sup>b</sup>
Jairam (2018)	Prospective	45;24	46.3	–	First stage	64% <sup>b</sup>	–
Chan (2020)	Retrospective	69	67 (Median)	23 (Median)	First stage	51%	90.3% (23 months)
Drossaerts (2015)	Prospective	98;59	54 (Median)	–	First stage	98% <sup>b</sup>	89% (60 months) <sup>b</sup>

Abbreviations: OAB, overactive bladder; PNE, peripheral nerve evaluation.

<sup>a</sup>Values in mean unless stated otherwise.

<sup>b</sup>Mixed OAB/CNOUR results.

<sup>c</sup>Potential population overlap.

<sup>d</sup>Responders.

**TABLE 2** Voiding parameters for patients with chronic nonobstructive urinary retention treated with sacral neuromodulation, following test stimulation and at long term follow-up after IPG implantation

First author (publication year)	Mean follow-up duration (months)	% Of catheter-free patients posttreatment	Decrease in mean PVR volume in ml (% change)	PVR volume posttest stimulation or at follow-up (range/ <i>SD</i> )	Decrease in mean no. of catheterization (% change)	Decrease in mean catheterized volume in ml (% change)	Increase in mean voided volume in ml (% change)
Outcomes following test stimulation phase <sup>a</sup>							
Chan (2020)	23 <sup>b</sup>	–	142 <sup>b,c</sup> (75.9)	45 <sup>b</sup> (150–21)	–	–	100 <sup>b</sup> (66.7)
Jairam (2018)	–	–	–	–	1.2 (22)	75 (31)	99.7 (50)
Marcelissen (2010)	53	–	–	–	0.2 (42.6)	–	171 <sup>c</sup> (64.0)
Lombardi (2013)	55	–	254.5 (75)	101.8 (60–220)	2.8 (83.3)	–	–
Lombardi (2014)	50	–	252.9 <sup>c</sup> (72)	114.1(39.1)	2.9 (81.2)	–	–
Long-term outcomes following IPG implantation							
van Voskuilen (2006)	15.5	60	–	–	4.2 (77.9)	297.6 (62.5)	125 <sup>b</sup> (50.3)
Mehmood (2007)	68.4	–	374.1 <sup>c</sup> (93)	28.1 (24.4)	4.2 (75)	–	–
Marcelissen (2010)	53	–	–	–	2.8 (59.6) <sup>c</sup>	–	107 <sup>c</sup> (52.7)
Denzinger (2011)	51 <sup>b</sup>	–	215 <sup>b</sup> (61)	135 <sup>b</sup> (0–1600)	3 <sup>b,c</sup> (75)	–	150 (50)
Spinelli (2005)	13.8	–	–	–	2.8 <sup>c</sup> (69.9)	229.2 <sup>c</sup> (69.8)	–

Note: Values all in mean unless stated otherwise.

Abbreviations: IPG, implantable pulse generator; PVR, postvoid residual; *SD*, standard deviation.

<sup>a</sup>Responders results.

<sup>b</sup>Median.

<sup>c</sup>Significant results.

**TABLE 3** Complication rates following sacral neuromodulation for the treatment of chronic nonobstructive urinary retention

	Revision and explantation (C-D III)	Other complications (<CD III)
van Voskuilen A (2006)	Revision: Overall: <b>9.6%</b> IPG site pain: 6.5% Troublesome leg stimulation: 3.2%	Incomplete electrode migration: 3.2% Loss of efficacy after non-urological surgery: 6.5% (treated by re-programming)
Saber-Khalaf (2015)	Explantation: Overall: <b>15.4%</b> Repeated need for MRI: 7.7% Aphasia: 7.7%	–
Mehmood (2007)	Explantation Overall: <b>16.6%</b> Loss of efficacy: 8.3% IPG site infection: 4.2% Stroke: 4.2%  Revision Overall: <b>41.6%</b> IPG site infection: 12.5% Battery expiration: 12.5% IPG site pain: 8.3% Implant migration: 8.3%	Undesirable sensation: 12.5% Leg pain: 8.3% UTI: 8.3% Pelvic/urethral pain: 8.3%
Marcelissen (2010)	Explantation Overall: <b>10.8%</b> Loss of efficacy: 4.7% Persistent stimulation related pain: 3.1% Psychiatric reason: 1.6% Repeated need for MRI: 1.6%  Revision Battery expiration: 6.3% IPG site pain: 10.9% Loss of efficacy: 4.7% Lead site pain: 1.6% Lead migration: 1.6%	Haematoma: 5.1% Loss of efficacy: 3.4% (INS turned off permanently) Reduced mobility requiring suprapubic catheter: 1.7% (INS turned off permanently) Wound infection: 1.7% Pain: 1.4% (treated by re-programming)
Lombardi (2014)	–	Pain at IPG site: 11.7% New pain/undesirable change in stimulation: 5.9% Adverse change in bowel function: 5.9%
Denzinger (2011)	Explantation No relevant improvement: <b>1.1%</b>  Revision Discomfort due to extensive weight loss: <b>12.5%</b>	Phlegmonous infection: 5.6%
Chan (2020)	Explantation Loss of efficacy: <b>9.7%</b>	–

Note: Red, reported overall explantation rate; Blue, reported overall revision rate.

Abbreviations: CD, Clavien–Dindo; IPG, implantable pulse generator.

were both authored by Van Balken et al.<sup>25,26</sup> with one focusing largely on prognostic factors for PTNS and have minimal data for extraction.<sup>26</sup> Success rates or improvement in voiding parameters were determined at the end of a 12-weekly treatment regimen of 30 min each, for all studies.

### 3.2.2 | Efficacy—adult population

All the studies defined the overall success rate subjectively, as the number of requests for continuation of treatment which ranges from 50% to 59%. The objective success rate which was defined as having at least a 50%

reduction in any of the troubling symptoms was reported to be 25% by Van Balken<sup>26</sup> and 41% by Vandoninck et al. Overall, 39% of patients in the study by Vandoninck et al. study achieved a mean catheterized volume of less than 100 ml. At the end of the treatment period, seven patients in this study catheterized just once daily but no one became catheter-free. A total of 26% of the patients in the same study reported at least a 25% reduction in PVR from a median of 270 ml at baseline to 220 ml after treatment, with a median change of 80 ml ( $p < 0.01$ ; Table 4).

### 3.2.3 | Efficacy—pediatrics population

In the pediatric study,<sup>27</sup> five of seven patients no longer need to strain to void and one of three achieved continence. On top of that, four of six children experienced a decrease in their PVR volume, from a mean of  $173 \pm 44 - 154 \pm 102$  ml ( $p = 0.3$ ; Table 4).

### 3.2.4 | Safety and complications

Minimal complications were reported following PTNS. Complications reported included transient pain, lower back pain, diarrhea, headaches, and calf cramps.

The risk of bias assessment revealed a high risk of detection bias as none of the included studies reported blinding of the outcome assessors. Selection bias was also present in a few of the studies as the patients' population was not appropriately representative of the whole. Moreover, all the patients in one SNM study had previously undergone intravesical electrostimulation and responded well to it.<sup>13</sup> Overall, most studies included in this review were assessed to have an unclear risk of bias.

## 4 | DISCUSSIONS

This systematic review found that the success rate of the test stimulation phase in SNM for treatment of CNOUR patients is high with a median rate of success of 79.2% (range: 42.5%–100%). The median rate of success of SNM in the treatment of CNOUR in the long-term was 89.1% (range: 65.5%–100%). However, Lombardi et al's.<sup>13</sup> study which reported a 100% test phase success rate carries a significant selection bias, as explained above. The range of reported long-term success rate in this review is not significantly different from that of the open technique for non-tined lead implantation, with two prospective studies reporting success rates of 52.8%<sup>28</sup> and 71%,<sup>29</sup> at a mean follow-up of 37.8 and 60 months, respectively.

TABLE 4 Treatment success rate and voiding parameters following treatment of chronic nonobstructive urinary retention with percutaneous tibial nerve stimulation

First author (publication year)	Number of participants	Subjective success rate (%)	Objective success rate (%)	Mean decrease in PVR volume (ml)	Mean decrease in no. of catheterization	Mean decrease in catheterized volume (ml)	Mean increase in total voided volume (ml)
Vandoninck (2003, 2004)	39	59	41	80; 100 <sup>a</sup>	0.5	76 <sup>b</sup>	116
Van Balken (2001)	12	58.3	–	–	0.8; 1.4 <sup>a</sup>	83.3; 131.9 <sup>a</sup>	173.8; 482.1 <sup>a</sup>
Van Balken (2006)	16	50	25	–	–	–	–

Abbreviation: PVR, postvoid residual.

<sup>a</sup>Total responders.

<sup>b</sup>Significant results.



Improvement was observed in all the voiding symptoms parameters at the end of test stimulation and at long-term follow-up after IPG implantation. Improvement in PVR volume was significant following SNM and this was demonstrated on both voiding diaries and urodynamics studies. Marcelissen et al.<sup>19</sup> reported that 60% of their patients became catheter free and similar results were demonstrated in the study by Mehmood et al.<sup>17</sup> which reported that almost all the patients could cease ISC following SNM. This illustrates the potential for SNM to reduce and even eliminate ISC in CNOUR patients.

A few predictive factors for SNM success were identified in this systematic review. Lombardi et al.<sup>13</sup> have identified the first sensation of bladder filling at baseline as a statistically significant predictable factor for first stage trial success of SNM. Both Chan<sup>21</sup> and Drossaerts<sup>22</sup> also found that the SNM success rate was much higher in patients with preserved bladder contractility as compared to those with bladder acontractility. Urodynamic studies before SNM can thus be helpful in identifying this group of patients and in counseling them about potential outcomes. Patient age is another significant predictive factor for the success of SNM in CNOUR. Chan et al.<sup>21</sup> identified an almost linear negative relationship between age and probability of SNM response while Saber-Khalaf et al.<sup>18</sup> identified a cut-off median age of 43 years whereby men (single-gender cohort) were less likely to respond if above that age. None of the complications reported were life-threatening. Mehmood et al.<sup>17</sup> reported a revision rate of 41.6% which is much higher than the rest of the studies (all lesser than 20%), likely because it also listed battery expiration as a type of complication (12.5%). Marcelissen et al.<sup>19</sup> has also done the same and reported the mean duration till battery replacement to be 62.3 months. The studies included in our review reported lower reoperation rates (median revision rate of 17.2% and explantation rate of 10.8%) than the open-technique studies which reported rates of 66%<sup>28</sup> and 48.3%.<sup>30</sup> This is most likely attributed to the percutaneous technique which has allowed for more accurate lead placement and the nature of the self-anchoring tined leads which have a smaller tendency to migrate.

In comparison to SNM, PTNS is a less invasive technique associated with minimal adverse events. It is also minimally painful, making it ideal for pediatrics patients. In the adult population, the success rate was much lower than SNM with the highest reported subjective rate being 59%. Voiding parameters improvement was also not as significant as that observed in SNM. The lack of constant stimulation to the bladder in PTNS to provide sustained effect could explain its failure in producing satisfactory results as observed in SNM. Furthermore, the objective success rate (25% and 41%) was

much lower than the subjective success rate which could suggest that even though a positive effect was experienced, the frequency or total duration of the therapy (12 weekly, 30 min each) was too short for adequate objective improvement to be observed. A period of maintenance therapy following the initial treatment course might produce a larger improvement than what had been observed, but further studies would be required to elucidate this point. Finally, even though the results for PTNS pediatrics patients were promising with reports of both subjective and object improvement, there was only one available study. The authors, therefore, conclude that there is currently insufficient evidence to support the use of PTNS in the treatment of CNOUR and it should only be considered as an experimental treatment option. The newer implantable PTNS may have potential but there is still no published data on this.

There are several limitations to this systematic review. First, all studies included in this review are Level IV evidence studies (pre-post studies) with no comparative or control arm. The absence of high-quality studies needs to be considered when interpreting the results of this study. Second, the causes of CNOUR and severity of urinary retention varied across the studies, as such the baseline patient population was considerably different. Some studies also included a mixed cohort of patients with other urological conditions such as OAB. The authors excluded studies that did not have voiding parameters outcomes exclusive to CNOUR patients. Third, many studies only included a small sample size which can artificially inflate the effect size, leading to imprecise interpretation of the overall success rate. Even though exclusion criteria were only applied to the SNM studies, all the SNM and PTNS adults' studies have a minimum of 10 patients, ensuring that results between the two neuromodulatory techniques were comparable. Fourth, many studies did not report on long-term follow-up outcomes which is an important consideration. Even when reported, many did not report the number of patients lost to follow-up and the reasons for lost to follow-up which may again introduce selection bias to the results. Therefore, the risk of bias and confounding in this review was significant. Given the heterogeneity of the studies and the limitations stated above, the authors did not combine the results from the different studies in quantitative analysis. Finally, there was a limited number of studies on PTNS for CNOUR to draw any meaningful conclusions. Additionally, no long-term outcome was reported by these PTNS studies and the definition of success is subjective, rather than objective improvement in patient-reported outcome measures or voiding parameters which is important when assessing the impact on urinary retention. Further studies to evaluate

the role of PTNS in the treatment of CNOUR is therefore warranted.

## 5 | CONCLUSION

This systematic review demonstrates that SNM is an effective and safe treatment modality for patients suffering from refractory CNOUR, with durable efficacy in the long term. Young age, smaller bladder volume at the first sensation, and a degree of preserved bladder contractility are positive predictors of success. There is insufficient evidence to support the use of PTNS for the treatment of CNOUR despite a lower reported complication rate. Further prospective studies to define the role of PTNS in the treatment of CNOUR are warranted.

### CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

### AUTHOR CONTRIBUTIONS

Felicia Ching Siew and Carl He: *Data collection, data analysis, manuscript writing.* Henry Han-I Yao and Johan Gani: *Protocol development, data collection, manuscript writing, supervision.* Helen E. O'Connell: *Protocol development, manuscript editing, supervision.*

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### REFERENCES

1. Overview | Sacral nerve stimulation for idiopathic chronic non-obstructive urinary retention | Guidance | NICE. 2015. <http://www.nice.org.uk/guidance/ipg536>
2. Gross C, Habli M, Lindsell C, South M. Sacral neuromodulation for nonobstructive urinary retention. *Female Pelvic Med Reconstr Surg.* 2010;16(4):249-253.
3. Jonas U, Fowler CJ, Chancellor MB, et al. Efficacy of sacral nerve stimulation for urinary retention: results 18 months after implantation. *J Urol.* 2001;165(1):15-19.
4. Coyne K, Wein A, Tubaro A, et al. The burden of lower urinary tract symptoms: evaluating the effect of LUTS on health-related quality of life, anxiety and depression: EpiLUTS. *BJU Int.* 2009;103:4-11.
5. Pinder B, Lloyd A, Elwick H, Denys P, Marley J, Bonniaud V. Development and Psychometric validation of the Intermittent Self-Catheterization Questionnaire. *Clin Ther.* 2012;34(12):2302-2313.
6. Tanagho E, Schmidt R. Electrical stimulation in the clinical management of the neurogenic bladder. *J Urol.* 1988;140(6):1331-1339.
7. Spinelli M, Weil E, Ostardo E, et al. New tined lead electrode in sacral neuromodulation: experience from a multicentre European study. *World J Urol.* 2005;23(3):225-229.
8. Spinelli M, Giardiello G, Gerber M, Arduini A, van den Hombergh U, Malaguti S. New sacral neuromodulation lead for percutaneous implantation using local anesthesia: description and first experience. *J Urol.* 2003;170(5):1905-1907.
9. Staskin D, Peters K, MacDiarmid S, Shore N, de Groat W. Percutaneous tibial nerve stimulation: a clinically and cost effective addition to the overactive bladder algorithm of care. *Curr Urol Rep.* 2012;13(5):327-334.
10. MBS online—New MBS items for percutaneous tibial nerve stimulation (PTNS) for the treatment of idiopathic overactive bladder. 2021. <http://www.mbsonline.gov.au/internet/mbsonline/publishing.nsf/Content/Factsheet-PTNS>. Accessed 20 October 2020.
11. National Heart Lung and Blood Institute, National Institutes of Health. Study Quality Assessment Tools. 2020. <https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools>
12. McGuinness LA, Higgins JPT. Risk-of-bias VISualization (robvis): an R package and Shiny web app for visualizing risk-of-bias assessments. *Res Syn Meth.* 2020;12:1-7.
13. Lombardi G, Musco S, Celso M, et al. Intravesical electrostimulation versus sacral neuromodulation for incomplete spinal cord patients suffering from neurogenic non-obstructive urinary retention. *Spinal Cord.* 2013;51(7):571-578.
14. Lombardi G, Musco S, Celso M, Del Corso F, Del Popolo G. Sacral neuromodulation for neurogenic non-obstructive urinary retention in incomplete spinal cord patients: a ten-year follow-up single-centre experience. *Spinal Cord.* 2014;52(3):241-245.
15. Van Voskuilen AC, Oerlemans DJ, Weil EH, van den Hombergh U, Van Kerrebroeck PE. Medium-term experience of sacral neuromodulation by tined lead implantation. *BJU Int.* 2007;99(1):107-110.
16. Denzinger S, Nowrotek A, Weingart P, et al. Does sacral neuromodulation lead to relevant reduction in the need for intermittent catheterization? A single-center experience on patients with chronic urinary retention, neuromodulation: technology at the neural. *Interface.* 2012;15(6):586-591.
17. Mehmood S, Altaweel WM. Long-term outcome of sacral neuromodulation in patients with idiopathic nonobstructive urinary retention: single-center experience. *Urol Ann.* 2017;9(3):244-248.
18. Saber-Khalaf M, Abtahi B, Gonzales G, Helal M, Elneil S. Sacral neuromodulation outcomes in male patients with chronic urinary retention. *Neuromodulation.* 2015;18(4):329-334.
19. Marcelissen TA, Leong RK, de Bie RA, van Kerrebroeck PE, de Wachter SG. Long-term results of sacral neuromodulation with the tined lead procedure. *J Urol.* 2010;84(5):1997-2000.

20. Jairam R, Drossaerts J, Marcelissen T, van Koevinge G, van Kerrebroeck P. Onset of action of sacral neuromodulation in lower urinary tract dysfunction-what is the optimal duration of test stimulation? *J Urol*. 2018;199(6):1584-1590.
21. Chan G, Qu LG, Gani J. Evaluation of pre-operative bladder contractility as a predictor of improved response rate to a staged trial of sacral neuromodulation in patients with detrusor underactivity. *World J Urol*. 2020.
22. Drossaerts J, Rademakers K, van Koevinge G, van Kerrebroeck P. The value of urodynamic tools to guide patient selection in sacral neuromodulation. *World J Urol*. 2015;33(11):1889-1895.
23. Vandoninck V, van Balken M, Finazzi Agrò, et al. Posterior tibial nerve stimulation in the treatment of idiopathic non-obstructive voiding dysfunction. *Adult Urol*. 2003;61(3):567-572.
24. Vandoninck V, van Balken M, Finazzi Agrò E, et al. Posterior tibial nerve stimulation in the treatment of voiding dysfunction: Urodynamic data. *NeuroUrol Urodyn*. 2004;23(3):246-251.
25. Van Balken MR, Vandoninck V, Gisolf KW, et al. Posterior tibial nerve stimulation as neuromodulative treatment of lower urinary tract dysfunction. *J Urol*. 2001;166(3):914-918.
26. Van Balken MR, Vergunst H, Bemelmans BLH. Prognostic factors for successful percutaneous tibial nerve stimulation. *Eur Urol*. 2006;49(2):360-365.
27. De Gennaro M, Capitanucci ML, Mastracci P, Silveri M, Gatti C, Mosiello G. Percutaneous tibial nerve neuromodulation is well tolerated in children and effective for treating refractory vesical dysfunction. *J Urol*. 2004;171(5):1911-1913.
28. Weil E, Ruiz-Cerda J, Eerdmans P, Janknegt R, Van Kerrebroeck P. Clinical results of sacral neuromodulation for chronic voiding dysfunction using unilateral sacral foramen electrodes. *World J Urol*. 1998;16:313-321.
29. van Kerrebroeck P, van Voskuilen A, Heesakkers J, et al. Results of sacral neuromodulation therapy for urinary voiding dysfunction: outcomes of a prospective, worldwide clinical study. *J Urol*. 2007;178(5):2029-2034.
30. van Voskuilen A, Oerlemans D, Weil E, de Bie R, van Kerrebroeck P. Long term results of neuromodulation by sacral nerve stimulation for lower urinary tract symptoms: a retrospective single center study. *Eur Urol*. 2006;49(2):366-372.

## SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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