European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 7, Issue 08, 2020

EFFECT of TRANSCUTANEOUS VERSUS PERCUTANEOUS TIBI AL NERVE STIMULATION on OVERACTIVE BLADDER in POSTMENOPAUSAL WOMEN

Khaled Sayed Ahmed[#1], Salwa Mostafa El Badry[2], Abeer Mohamed ElDeeb[3] & Mohamed Ramadan Rehan[4]

[#1]Assistant Lecturer of Physical Therapy for Women's Health, Faculty of Physical Therapy, Horus University, Egypt

[2]Professor of Physical Therapy for Women's Health, Faculty of Physical Therapy, Cairo University, Egypt

[3]Professor of Physical Therapy for Women's Health, Faculty of Physical Therapy, Cairo University, Egypt

[4]Lecturer of Urology, Faculty of Medicine, Al-Azhar university, Damietta, Egypt

[#1]ksayed@horus.edu.eg

Abstract: Background and Purpose: Comparing transcutaneous effects versus percutaneous tibial nerve stimulation on overactive bladder in postmenopausal women. Subjects and Methods: It was a randomized controlled trial. 60 postmenopausal women with overactive bladder, age were55-65years, divided to3 groups. Control received medical drugs in the form of selective anti Muscarinic drugs (10mg) once daily for 12 weeks. Transcutaneous tibial nerve stimulation (TTNS) group received the same medical treatment and TTNS, 3 sessions/week for 12 weeks. Percutaneous tibial nerve stimulation (PTNS) group received the same medical treatment and PTNS, 3 sessions/week for 12 weeks. Urodynamic investigation system was used to assess volumes in first desire for void and maximum bladder capacities (MBC) and overactive bladder questionnaire short form use for assessment the bladder severity symptoms and health related quality of life (HRQoL). Results Statistical analysis showed that the volume at first desire to void, MBC, and HRQoL significantly increased (P=0.0001) in all groups post treatment, while bladder severity symptoms significantly reduced (p=0.0001) in all groups after treatment. Also, Significantly differences among the control and TTNS in favor of TTNS (p= 0.0001), as well as between the control group and PTNS group in favor of PTNS (p= 0.0001) in all variables. However, no significantly differ (P>0.05) among TTNS group and PTNS group after treatment in all variables. Conclusions: TTNS is as effective as PTNS in decreasing bladder severity symptoms and improving HRQoL in postmenopausal women with overactive bladder.

Keywords: Transcutaneous tibial nerve stimulation, percutaneous tibial nerve stimulation, overactive bladder, postmenopausal women

INTRODUCTION

Overactive bladder (OAB) is a condition characterize by urination with urgency sense, urination frequency, and nocturia, with / without incontinence, which can negatively affect

the case's qualities of life included social interactions, sexual functions, sleeping, and mental health [1].

The prevalence of OAB is14-16% in the general population. The total cost for diagnosis and treatment of OAB is comparable for osteoporosis costs as well as breast cancers [2].

Causes of OAB are multifactorial. There may be injury to central inhibitory neural pathway, with / without deregulation of afferent sensory bladder pathway[3].

Untreated OAB could had negative impacts on case's psychological well-being, quality of life due to increased falling risks, vaginal risks and groin infection, fracturing a hip, and losing independence[4].

Several treatments options reported for management of OAB in elderly with preference for non-surgical methods because it does not worsen success rates of subsequent treatment, and low adverse side effect[5].

Previous studies reported that the percutaneoustibial nerve stimulation (PTNS) showed improvement of QoL or willingness to continue treatment, a decrease in urge incontinence, and a reduction in daytime and/or night-time frequency [6].However, the need for repeated treatments by PTNS places a great burden on patients and health professionals [7].Also, PTNS is associated with bruising or bleeding at needle site[8].

Transcutaneous tibial nerve stimulation (TTNS) is effective in treating OAB through decreasing the daytime and night-time urinary frequency, increasing voided volume, as well as decreasing urgency episodes and urgency incontinence, by relaxed bladder muscle and improve QoL[9].

To authors' knowledge, there is no previous study that compare the effect of PTNS and TTNS on overactive bladder. Our target was comparing TTNS effects to PTNS on bladder severity symptoms and improvement of HRQoL in postmenopausal women with overactive bladder. It was hypothesized that it would be no difference between the effect of TTNS and PTNS on OAB in postmenopausal women.

METHODS

Design

Our study is prospective, randomized, controlled trial done betweenMay 2019 and March 2020. Our protocol explain for every case sign the inform consent at starting of this study.

Our protocol approved by Ethical Committee for Faculty of Physical Therapy at Cairo University (P.T.REC/012/002517). The study was registered in the Pan African Registration Trials (PACTR201911868991836).

Participants

60 patients recruited from urology Outpatient Clinic, AL- AZHAR Hospital, New Damietta city. Our criteria's include postmenopausal women experienced menopause at least 3 years and suffered from overactive bladder and age range from 55:65 years and BMI ranged from 25:29.9 kg/m^2. Subjects were excluded if there were urinary tract infection, previous surgery for urinary incontinence, upper motor neuron diseases, history of genitourinary cancer, previous pelvic irradiation, pure stress urinary incontinence, genital prolapse, diabetes mellitus, pacemaker or metal implantation.

Randomization

60 cases randomly assign to 3 groups (control, TTNS group, PTNS group) with usingsealed envelope system by an independent person; the envelope contained a letter indicating whether the women would be allocated to control, TTNS or PTNS group. The patients were blinded about which group they were allocated.

Interventions
The patients in all groups received medical treatment in the form of selective anti Muscarinic drugs, (10 mg) once per day for 12 weeks [10].Medical treatment in form of selective antimuscarinics reduced amplitude of bladder contractions; improve bladder capacities and voluntary contraction. [11].

Transcutaneous tibial nerve stimulation (TTNS)
All patients in TTNS group received TTNS in electrodes placed as: negative electrode on medial ankle malleolus, and positive electrode ten cm to this point on right leg along nerve path. Both electrodes connect to conventional electrical stimulator produced pulses ranged from 10 : 50 mA accorded to patients sensitivities and hallux mobilizations[12]. All females were given some hallux mobilization degrees, which ensured tibial nerve is stimulated. Every session lasted thirty min, with pulse duration (200 μs) and frequency (10 Hz) in continuous mode. It was applied 3 times/week for 12 weeks.[13].

Percutaneous tibial nerve stimulation (PTNS)
The procedures of PTNS application consisted of tibial nerve stimulation through34-gauge needle electrode inserted 4–5 cm cephalad to medial malleolus. where site is the same one using in traditional Chinese acupuncture to relieve dysfunction of pelvic floor and pelvic organs[14].Every female position either supine or sitting with soles of feet together and her knees abducted and flexed. Pad placed at medial face of ipsilateral calcaneus as grounding. Needle electrode connect to external low voltage (9V) pulse generator and deliver the electrical pulse. female's response confirm throughout involuntary toe flexion of entire foot accompanied. A current level of 0.5-9 mA through fixed frequency (20 Hz) and pulse width (200μs) select and based on female's tolerance to associating discomforts.Protocol was applied and consisted of 3 times/week/ 30 minutes for 12 weeks.

OUTCOME MEASURES

1-Urodynamic parameters
Urodynamic Investigation System(serial No.(0084),PICO SMART, Menfis Division, MEDICA S.p.A., Bologna, Italy) was used to measure the volume at first desire to void and maximum bladder capacity (MBC).Traditional urodynamic testing remains the gold standard to objectively evaluate lower urinary tract function[15].It consists of acquisition unit up to 16 channels: pressure, electromyography, flow, volume, and leak point detector. The pressure channels are compatible both with external transducer for water perfused catheter. The urodynamic methodology comply with International Continence Society recommendations. Cystometry perform by patient supine through double lumen 8Fr catheter. Cystometry through used normal saline (25C to 30C),filling rate (50 ml / minute). Water filling stop when leakage occurred or cystometric volume become 400 ml. Volume at first involuntary detrusor contractions and at maximum cystometric capacities recorded[12] before and after 12 weeks for treatment.

2-Bladder symptoms severity and health related quality of life (HRQoL)
OAB questionnaire short form using for assessment bladder severities symptoms and HRQoL either pre or post treatments. Where self-administer patients-report outcome tools with 2 scales. It is internally consistent, valid, and responsive to treatment-related change [16]. OAB-q SF consisted of nineteen items comprised by 2 scales: six were Symptom Bother and thirteen were HRQoLscale.Full instructions were given for each woman who took a sufficient

time to select the best answer that described the extent to which she was bothered by each symptom. Then, the scores of the listed items for each patient subscale were summed and a specific formula was used to transform the value. Higher score values indicated greater symptoms severity and lower scores indicated minimal symptoms severity [17].

Statistical analysis

Data were performed by usedone-way ANOVA.Post-hoc (Tukey) test was conducted to perform multiple comparisons between all significant variables in the three groups. Results analyzed by using SPSSversion26. $p \leq 0.05$ was significant.

Results

Randomized cases completed trial and groups were similar at baseline (Fig. 1,Tab. 1).

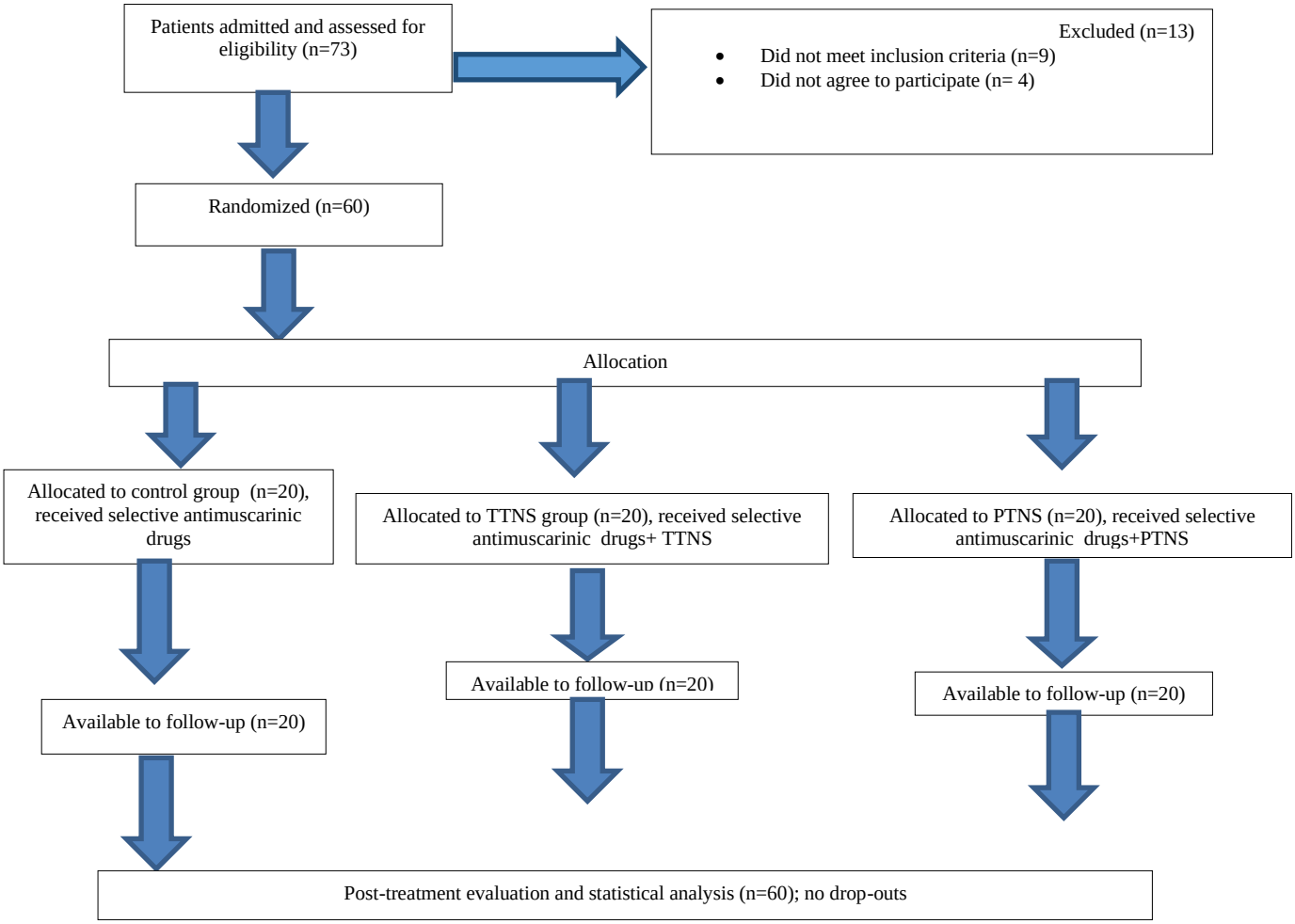

Figure 1. Flow chart of the randomized trial

Table 1.Demographic data of patients in all groups

	Control group	**TTNS**	**PTNS**	**F- value**	**p-value**
	$\overline{X}$ ±SD	$\overline{X}$ ±SD	$\overline{X}$ ±SD		
Age (years)	60.05± 3.1	60.25 ± 3.72	60.95 ± 2.54	0.446	0.64^{NS}
Weight (kg)	83.25 ± 6.98	84.1 ± 5.06	83.1 ± 5.47	0.167	0.85^{NS}
Height (cm)	176.05 ± 5.66	173.55 ± 5.26	177.35 ± 4.14	2.91	0.063^{NS}

BMI (kg/m²)	23.63± 1.68	24.24 ± 1.62	23.42 ± 1.33	1.52	0.23 ^{NS}

P: probability; NS: non-significant

Statistical analysis indicated that volume at first desire to void, MBC, and HRQoL showed a significant increase (p=0.0001) in the control group, TTNS group, and PTNS group post treatment. While bladder severity symptoms showed a significant decrease (p=0.0001) in the control group, TTNS group, and PTNS group posttreatment.

Results showed that volume at first desire to void, MBC, and HRQoL revealed significant increase between the control group and TTNS group posttreatment (p=0.0001) in favor of TTNS group. Also, there was a significant increase (p=0.0001) between the control group and PTNS group posttreatment in favor of PTNS group. However, there was no significant difference between TTNS group and PTNS group posttreatment in volume at first desire to void (p= 0.81), MBC (p= 0.94), and health related quality of life (p= 0.57).

While, bladder severity symptoms showed a significant decrease between the control group and TTNS group posttreatment(p=0.0001) in favor of TTNS group. Also, there was a significant decrease between the control group and PTNS group posttreatment (p=0.0001) in favor of PTNS group, while there was no significant difference (p= 0.94) between TTNS group and PTNS group posttreatment (Tables 2 and 3).

Table 2. Descriptive statistics for variables in studied groups at measuring points

Variable	Control group			TTNS group			PTNS group		
	Pre	Post	P-value	Pre	Post	P-value	pre	post	p-value
Volume at first desire to void	115.85 ± 9.92	158.45±13.04	**0.0001***	(116.4± 9.11)	205±16.4	**0.0001***	114.45 ± 8.45	208±14.28	**0.0001***
MBC	262.95± 11.75	308.35±8.88	**0.0001***	262.65± 13.44	355±20.28	**0.0001***	263.45 ± 13.2	353.8±17.53	**0.0001***
Bladder severity symptoms	64.13± 13.81	53.19±9.89	**0.0001***	65.96± 14.45	41.3±12.12	**0.0001***	65.61 ± 14.06	42.45±12.36	**0.0001***
HRQoL	48.63± 9.26	62.92±5.87	**0.0001***	47.18± 8.68	73.61±8.14	**0.0001***	48.09 ± 9.71	76.19±9.82	**0.0001***

Data are represented as mean ± standard deviation (SD), MBC: Maximum Bladder Capacity HRQoL: Health Related Quality of Life, *P<0.05

Table 3.Multiple comparisons between groups in all variables

Between groups				
Variable	**Measurement**	**Control group vs. TTNS group**	**Control group vs. TTNS group**	**TTNS vs. PTNS**
Volume at first desire to void	Pre	0.7877	0.7877	0.7877
	Post	0.0001*	0.0001*	0.818
MBC	Pre	0.9803	0.9803	0.9803
	Post	0.0001*	0.0001*	0.945
Bladder severity symptoms	Pre	0.9096	0.9096	0.9096
	Post	0.0001*	0.0001*	0.947
HRQoL	Pre	0.8819	0.8819	0.8819
	Post	0.0001*	0.0001*	0.577

Data are represented as mean ± standard deviation (SD), MBC: Maximum Bladder Capacity HRQoL: Health Related Quality of Life,*Significant level is set at alpha level <0.05

DISCUSSION

OAB affects patients' activities of daily living, as well as their HRQoL with those suffered from OAB-wet noted had higher impacts on sociality activity and work commitment [18].

This study showed that both groups that received TTNS and PTNS improved urodynamic parameters, bladder symptoms severity, and HRQoL with no significant difference between both groups.

The results of this study agreed with a previous study that showed TTNS had an effect on decreasing daytime frequency, reducing urgency incontinence episodes and improving HRQoL in the management of patients with idiopathic OAB symptoms [19]. Also, Perissinotto et al**.,**[20]reported thatTTNS showed a significant reduction in urinary symptoms in women with OAB.

In addition, when directly compared to antimuscarinic drug treatment, TTNS producing similar improving in frequencies, urgencies, and urinary incontinence in idiopathic OAB females [21].

Moreover, the results were in line with a previous study, which reported that adding TTNS to standard first line behavioral intervention for bladder training and pelvic floor muscle were increase its effectively in improved frequencies, nocturia, and urgency urinary incontinence in older idiopathic OAB females [22].

Comparing among TTNS effect and OAB drugs showed, adding TTNS to extended release oxybutynin is effectively comparing to TTNS alone over 12 /24 weeks. TTNS effects sustain over 24 weeks whereas single drug therapy effects are lost [10],[23].

In agreement with PTNS therapy, this study was supported by Del Río-Gonzalez et al.,[24] who showed increase the PTNS therapy efficacy in OAB cases are primarily refractory to antimuscarinic treatments. All clinical and urodynamic parameters evaluated at PTNS treatment completion and had improving effects on most cases.

In addition, other studies showed that PTNS produced significantly improving in all daytime voiding frequencies, volume and leakage episodes, improvement in urge incontinence and diurnal frequency [6], [25] [26], [27], [28][29], [30], [31], [32], [33].

Previous studies reported that TTNS showed urodynamic modifications in patients with clinical OAB. There was a significant improvement in the first involuntary detrusor contraction, MBC, OAB symptoms, and HRQoL [9], [10] [12], [13], [34][35], [36].

Randomised control trial for100 cases where compared PTNS with medication had more improvement in favor of PTNS group [37]. Also, Klinger et al.,[38] and Peters et al**.,** [7] used PTNS therapy with cases had urodynamic evaluation and improving in bladder symptoms and urodynamic parameters post 12 weeks compared to baseline.

The obtained results remain in line [39] who found that, no significantly differ among treatments in variables assessed.

Booth et al.,[34] have reported that there is equal effectiveness for the two routes of administration and TTNS and PTNS have similar success rates in management of patients with overactive bladder.

2 established neuromodulation therapeutic modalities were PTNS and sacral nerve stimulation. PTNS aimed to stimulating sacral nerve plexus throughout afferent fibers for tibial nerve causing alteration of nerve signals involved in micturition reflex, which affects bladder behavior and function through peripheral neuromodulation[40].

The specific mechanism of TTNS action is unknown [35.However, it may be explained as follows. Neuromodulation was postulated to being the cross-signalling effects among sympathetic and parasympathetic postganglionic nerve terminals and synapses, caused nerve signals alterations involve in micturition reflex. Neurophysiological proces and neural circuits involved in control lower urinary tract. Stimulation of peripheral nerves and subsequent "cross-talk"at postganglionic neuroeffector junctions level could modulate transmission affecting bladder functions [40].

Amarenco et al.,[12] and Kabay et al.,[36] reported that volumes at first involuntary detrusor contractions and maxim. cystometric capacities increasedin OAB cases of neurogenic or idiopathic origin, who received TTNS which had positively effects on results and improving quality of life.

Disadvantage for using PTNS in dealing with chronic condition as OAB was need for repeat treatments in order to avoiding symptoms recurrence without ongoing treatment [41]. OAB symptoms deteriorate within first 3 to 6 weeks which placed great burden on cases [7]. TTNS had many advantages relatively cheap, non-invasive, and self-administered, easy to operate and no adverse side-effects [9].

LIMITATIONS

- Short study duration. Longitudinal investigation required to evaluating long- TTNS term effects on urodynamic parameters, urinary symptoms, bladder severity symptoms, and quality of life. More studies are needed to identify the most appropriate and effective parameters of neuromodulation. More studies are needed to compare between TTNS and other forms of oral pharmacology. More studies are needed to compare between a combination of TTNS and oral antimuscarinics versus intravescial injection with different forms of pharmacotherapy as Botulinum-A toxin. Also, more studies are needed to determine the efficacy of multimodal approach, which includes TTNS and other forms of physical therapy modalities for management of patients with OAB

CONCLUSIONS

The study demonstrated that TTNS is effective as compared with PTNS regarding decreasing bladder symptoms severity and improving HRQoL in postmenopausal women with overactive bladder.

Acknowledgments

Thanks for all individuals whose contributed to completion this investigation.

Disclosure statement

No financial interest or financial benefit received for this study.

Conflict of interest
No conflict of interest among the authors.

Funding
Our study did not received any specific grant, or not-for-profit sectors.

Ethical approval:
The study was approved by Ethics Committee of the Faculty of Physical Therapy at Cairo University (P.T.REC\012\002517). The study was registered in the Pan African Registration Trials (PACTR201911868991836).

Consent
The procedures of this study were explained to all participants, who signed consent form before the beginning of the study.

REFERENCES
[1] Gormley EA, Lightner DJ, Faraday M, Vasavada SP. Diagnosis and treatment of overactive bladder (non-neurogenic) in adults: AUA/ SUFU Guideline Amendment. J Urol. 2015;193: 1572– 1580.
[2] Hu TW, Wagner TH, Bentkover JD, Leblanc K, Zhou SZ, Hunt T.Costs of urinary incontinence and overactive bladder in the United States:acomparativestudy.Urology.2004;63(3):461-465.
[3] GillespieJI. Modulation of autonomous contractility activity in the isolated whole bladder of the guinea pig. BJU Int.,2004;93(3):393-400.
[4] Milson I. Overactive bladder: Current understanding and future issues. BJOG.2006.113 (Suppl 2):2-8.
[5] Borello FD,Burgio KL.Nonsurgical treatment of urinary incontinence. Clin Obstet Gynecol.2004; 47(1):70–82.
[6] Van der Pal F, van Balken MR, Heesakkers JPFA, Debruyne FMJ,Bemelmans BLH. Percutaneous tibial nerve stimulation in the treatment of refractory overactive bladder syndrome: is maintenance treatment necessary? BJU Int.2006;97(3):547–90
[7] Peters KM, Carrico DJ, Wooldridge LS, Miller CJ, MacDiarmidSA. Percutaneous tibial nerve stimulation for the long-term treat-ment of overactive bladder: 3-year results of the STEP study. J Urol.2013;189(6):2194–201.
[8] Staskin DR, Peters KM, MacDiarmid S, Shore N, de Groat WC. Percutaneous tibial nerve stimulation: a clinically and cost effective addition to the overactive bladder algorithm of care. CurrUrol Rep. 2012 Oct;13(5):327-34.
[9] Manriquez V, Guzman R, Naser M, Aguilera A, Narvaez S, Castro A,et al. Transcutaneous posterior tibial nerve stimulation versus extended release oxybutynin in overactive bladder patients. A prospective ran-domized trial. Eur J Obstet Gynecol Reprod Biol 2016;196:6–10.
[10] Souto SC, Reis LO, Palma T, Palma P, Denardi F. Prospective and randomized comparison of electrical stimulation of the posterior tibial nerve versus oxybutynin versus their combination for treatment of women with overactive bladder syndrome. World J Urol. 2014 Feb;32(1):179-84.
[11] Staskin DR. Overactive bladder in the elderly: a guide to pharmacological management. Drugs Ageing.2005; 22(12): 1013-28.
[12] Amarenco G, Ismael SS, Even-Schneider A, Raibaut P, Demaille-Wlodyka S, et al. Urodynamic effect of acute transcutaneous posterior tibial nerve stimulation in overactive bladder. J Urol 2003;169:2210–5.

[13] Schreiner L, dos Santos TG, Knorst MR, da Silva Filho IG. Randomized trial of transcutaneous tibial nerve stimulation to treat urge urinary incontinence in older women. IntUrogynecol J.2010; 21(9):1065-1070; doi: 10.1007/s00192-010-1165-6.
[14] Yoong W, Ridout AE, Damodaram M, Dadswell R.Neuromodulative treatment with percutaneous tibial nerve stimulation for intractable detrusor instability: outcomes following a shortened 6-week protocol. BJU Int. 2010 Dec;106(11):1673-6.
[15] Rosier PF. The evidence for urodynamic investigation of patients with symptoms of urinary incontinence. F1000Prime Rep. 2013;5:8.
[16] Coyne K, Revicki D, Hunt T, Corey R, Stewart W, Bentkover J, et al. Psychometric validation of an overactive bladder symptom and health-related quality of life questionnaire: the OAB-q. Qual Life Res. 2002 Sep;11(6):563-74.
[17] Coyne KS, Sexton CC, Irwin DE, Kopp ZS, Kelleher CJ,Milsom I. The impact of overactive bladder, incontinence and other lower urinary tract symptoms on quality of life, work productivity, sexuality and emotional well-being in men and women: results from the EPIC study''. Br J Urol. 2008;101(11):1388–95.
[18] Milsom I, Kaplan SA, Coyne KS, Sexton CC, Kopp ZS. Effect of bothersome overactive bladder symptoms on health-related quality of life,anxiety, depression, and treatment seeking in the United States: results from EpiLUTS. Urology. 2012;80(1):90–6.
[19] Ramírez-García I, Blanco-Ratto L, Kauffmann S, Carralero-Martínez A, Sánchez E. Efficacy of transcutaneous stimulation of the posterior tibial nerve compared to percutaneous stimulation in idiopathic overactive bladder syndrome: Randomized control trial. NeurourolUrodyn. 2019 Jan;38(1):261-268.
[20] Perissinotto MC, D'Ancona C, Lucio A, Campos, RN, Abreu A. Transcutaneous tibial nerve stimulation in the treatment of lower urinary tract symptoms and its impact on health-related quality of life in patients with parkinson disease a randomized controlled trial. J Wound OstomyContinence Nurs.2015;42(1)94–99.
[21] Manriques C, Guzmán R, Naser AM, Aguilera A, Narvaez S, Castro A, et al. Transcutaneous posterior tibial nerve stimulation versus extended release oxybutynin in overactive bladder patients. A prospective randomized trial. Eur J ObstetGynecolReprod Biol.2016 ;196:6–10;
[22] Schreiner L, dos Santos TG, Knorst MR, da Silva Filho IG. Randomized trial of transcutaneous tibial nerve stimulation to treat urge urinary incontinence in older women. IntUrogynecol J.2010; 21(9):1065-1070.
[23] Bellette P, Rodrigues-Palmer P, Hermann V,Riccetto C, Bigozzi M, OlivaresJM. Posterior tibial nerve stimulation in the management of overactive bladder. a prospective and controlled study. ActasUrols Esp.2009; 33(1):58–63.
[24] Del Río-Gonzalez S., Aragon IM, Castillo E, Milla-Espana F, Galacho A, Machuca J, et al. Percutaneous Tibial Nerve Stimulation Therapy for Overactive Bladder Syndrome: Clinical Effectiveness, Urodynamic, and Durability Evaluation. Urology.2017;108:52-58.
[25] Peters KM, Carrico DJ, Perez-Marrero RA, Khan AU, Wooldridge LS, Davis GL, et al. Randomized trial of percutaneous tibial nerve stimulation versus sham efficacy in the treatment of overactive bladder syndrome: results from the SUmiT trial. J Urol. 2010;183:1438–1443.
[26] Finazzi-Agro E, Petta F, Sciobica F, Pasqualetti P, Musco S, Bove P. Percutaneous tibial nerve stimulation effects on detrusor overactivity incontinence are not due to a placebo effect: a randomized, double-blind, placebo controlled trial. J Urol. 2010; 184(5):2001–2006.
[27] Ruiz BC, Outeirino XMP, Martinez PC, Duenas EL, Lopez AL. Peripheral afferent nerve stimulation for treatment of lower urinary tract irritative symptoms. Eur Urol. 2004;45(1):65–9.

[28] Vandoninck V, van Balken MR, Finazzi Agro E,Petta F, Micali F, Heesakkers JP, et al. Percutaneous tibial nerve stimulation in the treatment of overactive bladder: urodynamic data. NeurourolUrodyn. 2003;22(3):227–232.
[29] MacDiarmid SA, Peters KM, Shobeiri SA, Wooldridge LS, Rovner ES, Leong FC, et al. Long-term durability of percutaneous tibial nerve stimulation for the treatment of overactive bladder. J Urol. 2010;183(1):234–40.
[30] Van Balken MR, Vandoninck V, Gisolf KWH, Vergunst H, Kiemeney LA, Debruyne FM, et al. Posterior tibial nerve stimulation as a modulative treatment of lower urinary tract dysfunction. J Urol. 2001;166(3):914–8.
[31] Govier FE, Litwiller S, Nitti V, KrederJr KJ, Rosenblatt P. Percutaneous afferent neuromodulation for the refractory overactive bladder: results of a multicenter study. J Urol. 2001;165(4):1193–8.
[32] Van Rey FS, Heesakkers J. Applications of neurostimulation for urinary storage and voiding. UrologiaIntis. 2008;81(4):373–8.
[33] Arrabal-Polo MA, Palao-Yago F, Campon-Pacheco I, Martinez- Sanchez M, Zuluaga-Gomez A, Arrabal-Martin M. Clinical efficacy in the treatment of overactive bladder refractory to anticholinergics by posterior tibial nerve stimulation. Korean J Urol. 2012;53(7):483–6.
[34] Booth J, Connelly L, Dickson S, Duncan F, Lawrence M. The effectiveness of transcutaneous tibial nerve stimulation (TTNS) for adults with overactive bladder syndrome: A systematic review.Neurourology and Urodynamics.2018; 37(2):528–541
[35] Ammi M, Chautard D, Brassart E, Culty T, Azzouzi AR, Bigot P. Transcutaneous posterior tibial nerve stimulation: evaluation of a therapeutic option in the management of anticholinergic refractory overactive bladder. IntUrogynecol J. 2014;25(8):1065-1069.
[36] Kabay SC, Yucel M, Kabay S. Acute effect of posterior tibial nerve stimulation on neurogenic detrusor overactivity in patients with multiple sclerosis: urodynamic study. Urology. 2008;71(4):641–645.
[37] Peters KM, MacDiarmid SA, Wooldridge LS, Leong FC, Shobeiri SA, Rovner ES, et al. Randomized trial of percutaneous tibial nerve stimulation versus extended release tolterodine: results from the overactive bladder innovative therapy trial. J Urol. 2009;182(3):1055–61.
[38] Klingler HC, Pycha A, Schmidbauer J, Marberger M. The use of peripheral neuromodulation of the S3 region for treatment of detrusor overactivity: a urodynamic based study. Urology. 2000;56(5):766–71.
[39] Barroso U, Viterbo W, Bittencourt J, Farias T, Lordeˆlo P. Posterior tibial nerve vs. parasacral transcutaneous neuromodulation in the treatment of overactive bladder in children. J Urol. 2013 ;190(2):673-7.
[40] deGroat WC, Griffiths D, Yoshimura N. Neural control of the lower urinary tract. Compr Physiol. 2015;5(1):327–396
[41] Yoong W, Shah P, Dadswell R, Green, L. Sustained effectiveness of percutaneous tibial nerve stimulation for overactive bladder syndrome:2-year follow-up of positive responders. IntUrogynecol J.2013;24(5):795–9.