

Electrical Stimulation In Incontinence

(2000) Pelvic floor electrical stimulation in the treatment of adult urinary incontinence. *Tecnologica. MAP. Suppl* 15-17.

Abelli L., Ferri G.L., Astolfi M., Conte B., Geppetti P., Parlani M., Dahl D., Polak J.M., and Maggi C.A. (1991) Acrylamide-induced visceral neuropathy: evidence for the involvement of capsaicin-sensitive nerves of the rat urinary bladder. *Neuroscience* 41, 311-321.

Abstract: The mechanisms underlying the severe urinary retention induced by acrylamide intoxication were studied in detail in the rat. Subcutaneous treatment with acrylamide monomer (50 mg/kg daily for 10 days) almost completely impaired the micturition reflex, resulting in urinary retention. In fact, the ability to eliminate an oral water load was virtually abolished, while bladder filling with saline (transvesical cystometrogram) failed to activate reflex micturition. Instead, a picture of overflow incontinence resulted in urethane-anaesthetized rats, which was not reversed by intravenous administration of 4-aminopyridine. The nerve-mediated contractile response to field stimulation (0.1-20 Hz, 0.5 ms, 60 V) of the isolated bladder was unaffected, thus suggesting the integrity of bladder efferent innervation, and no evidence was found from in vitro experiments that the myogenic contractility of the bladder was depressed by acrylamide treatment. Conversely, the sensory nerve-mediated response to capsaicin was abolished and sensory nerve fibres of the bladder were selectively depleted of their content of substan

Aitchison M., Fisher B.M., Carter K., McKee R., MacCuish A.C., and Finlay I.G. (1991) Impaired anal sensation and early diabetic faecal incontinence. *Diabet. Med.* 8, 960-963.

Abstract: Faecal incontinence develops in up to 20% of diabetic patients. To try to determine the relative contributions of sensory and motor neuropathy in this troublesome complication, anorectal function was examined in 10 male diabetic patients with early faecal incontinence (mucus leakage or faecal staining without the need to wear a pad), 10 asymptomatic male diabetic patients, and 10 normal control subjects. Motor function was tested using anal manometry to determine the resting and maximum squeeze pressure, and the functional anal canal length. No significant differences were found between the groups. Sensory function was tested by measuring the mucosal sensitivity to electrical stimulation, and the response to inflation of a balloon in the rectum. In the mid-anal canal position the symptomatic patients had a significantly higher sensory threshold at 6.6 +/- 2.8 mA compared with 3.0 +/- 1.2 mA in the normal control subjects (p less than 0.002), and in the high anal zone symptomatic patients had a significantly elevated sensory threshold at 9.1 +/- 2.0 mA compared with 4.6 +/- 1.6 mA in asymptomatic patients and 3.6 +/- 1.3 mA in the normal control subjects (both p less than 0.001). There were no significant differences in the first sensation of fullness, maximum tolerated volume or percentage fall from resting pressure between the groups on inflation of the balloon. Elevation of the sensory threshold in the upper anal canal is an early abnormality in the development of diabetic faecal incontinence

Alexander S. and Rowan D. (1966) Closure of the urinary sphincter mechanism in anaesthetized dogs by means of electrical stimulation of the perineal muscles. *Br. J. Surg.* 53, 1053-1056.

Alexander S. (1976) A critical look at incontinence radio-implants. *Urol. Int.* 31, 129-133.
Abstract: Indwelling electrical stimulation of the pelvic floor by a radio-implant benefits some cases of problem or recurrent urinary incontinence. It is not possible to predict success or failure with a given patient. The only worthwhile criterion for selection is the presence of contraction of pelvic floor musculature in response to voluntary effort or trial electrical stimulation. The results are not simply explained by postulating electrically induced closure of the urethra. There may be conscious enhancement of the urinary sphincter mechanism. Re-education of voluntary sphincter muscles by electrophysiotherapy may occur. Reflex inhibition of the detrusor may occur. The surgery involved in inserting an implant restores continence in some patients

Andersson K.E., Andersson P.O., Fovaeus M., Hedlund H., Malmgren A., and Sjogren C. (1988) Effects of pinacidil on bladder muscle. *Drugs* 36 Suppl 7, 41-49.
Abstract: Infravesical outflow obstruction and bladder hypertrophy are often associated with bladder hyperactivity causing frequency, urge and urinary incontinence. This hyperactivity may be due to a supersensitivity to depolarising stimuli. Drugs that inhibit smooth muscle activity by opening K⁺ channels, resulting in hyperpolarisation, would therefore seem to be an attractive therapeutic principle. Pinacidil is an effective vasodilator classified as a K⁺ channel opener. The drug has been shown to effectively depress spontaneous contractile activity, the contractions induced by low (less than 40 mmol/L) concentrations of K⁺, carbachol and by electrical stimulation of nerves in isolated normal human bladder tissue and also in normal and hypertrophied rat bladder. The effect was more pronounced in hypertrophied detrusor. Pinacidil in concentrations inhibiting muscle activity also increased the efflux of ⁸⁶Rb in bladder tissue. In vivo pinacidil suppressed spontaneous contractile activity in rats with infravesical bladder obstruction and detrusor hypertrophy. The findings make K⁺ channel openers an interesting, potentially useful therapeutic principle in hyperactivity associated with bladder hypertrophy

Appell R.A. (1998) Electrical stimulation for the treatment of urinary incontinence. *Urology* 51, 24-26.
Abstract: OBJECTIVES: To describe the rationale for the use of electrical stimulation (ES) for the treatment of urinary incontinence, and to summarize the results of clinical studies assessing these techniques. METHODS: The effect of ES on the lower urinary tract (LUT) is explained, and the literature on clinical application of this technique is reviewed. RESULTS: The use of ES is aimed at altering LUT function by stimulation of the sacral autonomic or somatic nerves. Two types of ES have been used: chronic stimulation and acute maximal functional electrostimulation. The frequency used depends on the clinical diagnosis. In patients with stress incontinence, uncontrolled studies suggest that high frequency and high amperage are required to obtain a 50% success rate, although success does not necessarily equate with cure. The only placebo-controlled trial in this population found that 62% of patients experienced significant improvement on provocative pad test determinations, but only 20% were dry. Researchers agree that low frequency and moderate amperage are required in patients with detrusor instability. The reported effectiveness of ES in this population has ranged widely, from 45% to 91%, but all studies agree that approximately one-third of patients will obtain a good long-term results. A review of multiple studies found that 20% of patients were reported as dry and 37% were significantly improved with functional ES. CONCLUSIONS: Although

nearly all studies of ES have been uncontrolled, a substantial body of "soft" data attests to the efficacy and safety of this technique

Aristizabal Agudelo J.M., Salinas C.J., Fuertes M.E., Virseda C.M., Salman M.S., Bravo de Rueda A.C., and Resel E.L. (1996) [Urodynamic results of the treatment of urinary incontinence with peripheral electric stimulation]. Arch. Esp. Urol. 49, 836-842.

Abstract: OBJECTIVES: To evaluate the urodynamic results achieved by electrostimulation in patients with different types of urinary incontinence. METHODS: 37 patients (32 females and 5 males) with urinary incontinence were treated with peripheral electrical stimulation. The urodynamic diagnosis were: detrusor instability (24.3%), stress urinary incontinence (24.3%), mixed urinary incontinence (48.6%), and bladder hyper-reflexia (2.7%). Rectal and vaginal electrodes were utilized. The therapeutic frequencies were 10 Hz, 20 Hz and 50 Hz. RESULTS: Detrusor instability disappeared in the cases treated with the 10 Hz frequency (79%) and in one case treated with the 50 Hz frequency. A significantly increased bladder capacity and decreased first micturition sensation were observed in this patient group. All patients with stress urinary incontinence were treated with high frequency (50 Hz), which achieved positive results in 44%. In the group of patients with mixed urinary incontinence. 45% remained unchanged. Treatment failed to achieve satisfactory results in the single case of detrusor hyperreflexia in this series. CONCLUSION: Peripheral electrical stimulation is a valid alternative in the treatment of male and female incontinence. Satisfactory results were achieved with the 10 Hz frequency in 89% of the patients with bladder instability and with the 50 Hz frequency in 44% of the patients with stress urinary incontinence

Baeten C.G., Konsten J., Heineman E., and Soeters P.B. (1994) Dynamic graciloplasty for anal atresia. J. Pediatr. Surg. 29, 922-924.

Abstract: The aim of this study was to assess whether an electrically stimulated graciloplasty (dynamic graciloplasty) can achieve continence in nine patients with anal atresia (median age, 28 years; range, 18 to 40). As the first procedure, a gracilis muscle was transposed. Six weeks later, intramuscular electrodes were implanted and connected to a pulse generator. Eventually, the muscle was gradually trained, by electrical stimulation, to achieve fecal continence. Continence was obtained in five patients (55%). Manometry demonstrated an increase in mean anal pressure, from 36 mm Hg (without stimulation) to 52 mm Hg (with stimulation), after 8 weeks (mean increase, 16 mm Hg, [95% confidence interval, 8, 24 mm Hg; n = 9; P < .01). Failures resulted from a noncontracting distal part of the gracilis muscle (in three patients) and a nondistending rectum (in one patient). We conclude that dynamic graciloplasty can achieve continence in a substantial number of patients with thus-far untreatable incontinence after surgical correction for anal atresia

Balcom A.H., Wiatrak M., Biefeld T., Rauhen K., and Langenstroer P. (1997) Initial experience with home therapeutic electrical stimulation for continence in the myelomeningocele population. J. Urol. 158, 1272-1276.

Abstract: PURPOSE: In an attempt to enhance bladder and bowel continence 29 patients underwent long duration, low intensity transcutaneous therapeutic electrical stimulation. This technology has previously been shown to be effective for inducing regenerative hypertrophy of disuse atrophied skeletal muscle, and it has been associated with improved continence in the myelomeningocele population. Our objectives were to enhance urinary and fecal continence, and evaluate the

mechanisms by which therapeutic electrical stimulation influences continence. MATERIALS AND METHODS: A total of 29 children with lumbar or sacral myelomeningocele underwent therapeutic electrical stimulation at home during sleep using a commercially available stimulator with a safety sensing circuit and 2 sets of electrodes placed on the skin at bedtime. Left and right side electrode placement was alternated on 6 of 7 consecutive nights. In 9 boys and 2 girls with more than 9 months of followup initial and subsequent cystometrography, urethral pressure profile, electromyography, voiding cystourethrography and renal ultrasound studies were evaluated. RESULTS: In the 11 children there was no radiographic evidence of urinary tract or musculoskeletal deterioration during treatment. Mean actual bladder capacity increased from 133 to 196 ml. ($p < 0.05$). Mean bladder capacity, as a percent of maximum predicted bladder capacity for a normal age matched child without myelomeningocele, also significantly increased from 59 before to 76% after 9 months of therapeutic electrical stimulation ($p < 0.05$). No significant change was noted in urethral pressure profile. A subjective improvement in the sensation of pelvic fullness was also observed. CONCLUSIONS: When administered at home by parents while the child sleeps, therapeutic electrical stimulation is safe for bladder and bowel continence in the myelomeningocele population. It seems to increase significantly bladder capacity, does not appear to change urethral pressure profile and results in a subjectively improved sensation of pelvic fullness, enhancing urinary and fecal continence. The most beneficial effect of therapeutic electrical stimulation seems to be on the bladder wall and less so on the striated pelvic floor musculature with subjective enhancement of pelvic fullness also contributing positively

Bardoel J.W., Stadelmann W.K., Perez-Abadia G.A., Galandiuk S., Zonnevillje E.D., Maldonado C., Stremel R.W., Tobin G.R., Kon M., and Barker J.H. (2001) Dynamic rectus abdominis muscle sphincter for stoma continence: an acute functional study in a dog model. *Plast. Reconstr. Surg.* 107, 478-484.

Abstract: Fecal stomal incontinence is a problem that continues to defy surgical treatment. Previous attempts to create continent stomas using dynamic myoplasty have had limited success due to denervation atrophy of the muscle flap used in the creation of the sphincter and because of muscle fatigue resulting from continuous electrical stimulation. To address the problem of denervation atrophy, a stomal sphincter was designed using the most caudal segment of the rectus abdominis muscle, preserving its intercostal innervation as well as its vascular supply. The purpose of the present study was to determine whether this rectus abdominis muscle island flap sphincter design could maintain stomal continence acutely. In this experiment, six dogs were used to create eight rectus abdominis island flap stoma sphincters around a segment of distal ileum. Initially, the intraluminal stomal pressures generated by the sphincter using different stimulation frequencies were determined. The ability of this stomal sphincter to generate continence at different intraluminal bowel pressures was then assessed. In all cases, the rectus abdominis muscle sphincter generated peak pressures well above those needed to maintain stomal continence (60 mmHg). In addition, each sphincter was able to maintain stomal continence at all intraluminal bowel pressures tested

Bauchet L., Segnarbieux F., Martinazzo G., Frerebeau P., and Ohanna F. (2001) [Neurosurgical treatment of hyperactive bladder in spinal cord injury patients]. *Neurochirurgie* 47, 13-24.

Abstract: OBJECTIVES: We report long-term results of posterior sacral root rhizotomies in combination with Finetech-Brindley anterior sacral root stimulators

implanted intradurally in 20 spinal cord injury patients. MATERIAL: and methods: The 14 female and 6 male patients included 14 paraplegics and 6 tetraplegics. All of them initially presented hyperactive bladder, detrusor-sphincter dyssynergia, recurrent urinary tract infection and performed (self) intermittent catheterization. Prior to implantation, an intrathecal test using bupivacaine was performed to confirm the compliances of the bladder. The main indication for implantation was persistent urinary incontinence refractory to medical therapy. RESULTS: After implantation the mean follow-up was 4,5 years. In all, 18 patients used the stimulator alone for bladder emptying and 18 patients were completely continent. The mean bladder capacity increased from 190 ml preoperatively to 460 ml after the operation. The mean residual urinary volume was reduced from 90 ml to 25 ml. No changes were noted by renal isotopic scanning in upper urinary tracts of patients. In 1 patient, a second extradural implant was performed. DISCUSSION: This article also include an overview of a) the different available sites where application of electrical stimulation results in a detrusor contraction, b) the benefits and disadvantages of the sacral posterior rhizotomy, c) selective stimulation techniques that allow selective detrusor activation by sacral root stimulation. CONCLUSION: Sacral anterior root stimulation combined with sacral posterior rhizotomy is a valuable method to restore bladder functions in spinal cord injured patients suffering from hyperactive bladder refractory to medical therapy

Beckman N.J. (1995) An overview of urinary incontinence in adults: assessments and behavioral interventions. *Clin. Nurse Spec.* 9, 241-7, 274.

Abstract: Urinary incontinence affects millions of Americans. Often the goal of treatment is to improve the condition, prevent complications and provide comfort. Behavioral interventions can improve the condition in 54-75% of patients with urge and/or stress incontinence and can cure 12- 16% of patients. Advanced practice nurses (APNs) are in a unique position of both providing direct care to patients who experience these problems and educating other nurses about signs, symptoms and appropriate nursing interventions for urinary incontinence. The scope of the problem, costs of urinary incontinence and potential cost savings with treatment are discussed in this article. Acute and chronic urinary incontinence and the necessary assessments to be performed by the APN are reviewed. Bladder training, habit training, prompted voiding and pelvic muscle exercises are the behavioral interventions used with urinary incontinence. Adjunct therapy, including biofeedback, vaginal cones and electrical stimulation, also is discussed

Benson J.T. (2000) Sacral nerve stimulation results may be improved by electrodiagnostic techniques. *Int. Urogynecol. J. Pelvic. Floor. Dysfunct.* 11, 352-357.

Abstract: Sacral nerve electrical stimulation (sacral neuromodulation) therapy for patients with refractory urge incontinence, frequency and urgency, and non-obstructive retention yields an effective 75%-80% success rate. Electrodes are surgically implanted if initial percutaneous stimulation testing has a successful clinical response. Unfortunately, up to 50% of patients are denied surgical implantation because of an unsuccessful response to the test stimulation. In this descriptive study, adding electrodiagnostic monitoring to the currently used biological monitoring techniques was associated with a reduction in the number of tested patients denied implantation to 20%. These findings suggest that the incorporation of electrodiagnostic techniques may improve the clinical efficacy of sacral stimulation therapy. Randomized prospective testing of this hypothesis is suggested

Berghmans L.C., Hendriks H.J., Bo K., Hay-Smith E.J., de Bie R.A., and van Waalwijk van Doorn ES (1998) Conservative treatment of stress urinary incontinence in women: a systematic review of randomized clinical trials. *Br. J. Urol.* 82, 181-191. Abstract: OBJECTIVE: To assess the efficacy of physical therapies for first-line use in the treatment and prevention of stress urinary incontinence (SUI) in women, using a systematic review of randomized clinical trials (RCTs). MATERIALS AND METHODS: A computer-aided and manual search for published RCTs investigating treatment and prevention of SUI using physical therapies, e.g. pelvic floor muscle (PFM) exercises, with or without other treatment modalities, were carried out. The methodological quality of the included trials was assessed using criteria based on generally accepted principles of interventional research. RESULTS: Twenty-four RCTs (22 treatment and two prevention) were identified; the methodological quality of the studies included was moderate and 11 RCTs were of sufficient quality to be included in further analysis. Based on levels-of-evidence criteria, there is strong evidence to suggest that PFM exercises are effective in reducing the symptoms of SUI. There is limited evidence for the efficacy of high- intensity vs a low-intensity regimen of PFM exercises. Despite significant effects of biofeedback after testing as an adjunct to PFM exercises, there is no evidence that PFM exercises with biofeedback are more effective than PFM exercises alone. There is little consistency (of stimulation types and parameters) in the studies of electrical stimulation, but when the results are combined there is strong evidence to suggest that electrostimulation is superior to sham electrostimulation, and limited evidence that there is no difference between electrostimulation and other physical therapies. In the prevention of SUI the efficacy of PFM exercises, with or without other adjuncts, is uncertain

Berghmans L.C., Hendriks H.J., de Bie R.A., van Waalwijk van Doorn ES, Bo K., and van Kerrebroeck P.E. (2000) Conservative treatment of urge urinary incontinence in women: a systematic review of randomized clinical trials. *BJU. Int.* 85, 254-263. Abstract: OBJECTIVE: To assess the efficacy of physical therapies for first-line use in the treatment of urge urinary incontinence (UUI) in women, using a systematic review of randomized clinical trials (RCTs). MATERIALS AND METHODS: A computer-aided and manual search was carried out for RCTs published between 1980 and 1999 investigating the treatment of UUI defined by the keywords 'physical therapies', e.g. bladder (re)training (including 'behavioural' treatment), pelvic floor muscle (PFM) exercises, with or without biofeedback and/or electrical stimulation. The methodological quality of the included trials was assessed using methodological criteria, based on generally accepted principles of interventional research. RESULTS: Fifteen RCTs were identified; the methodological quality of the studies was moderate, with a median (range) score of 6 (3-8.5) (maximum possible 10). Eight RCTs were considered of sufficient quality, i.e. an internal validity score of \geq 5.5 points on a scale of 0-10, and were included in a further analysis. Based on levels-of-evidence criteria, there is weak evidence to suggest that bladder (re)training is more effective than no treatment (controls), and that bladder (re)training is better than drug therapy. Stimulation types and parameters in the studies of electrical stimulation were heterogeneous. There is insufficient evidence that electrical stimulation is more effective than sham electrical simulation. To date there are too few studies to evaluate effects of PFM exercise with or without biofeedback, and of toilet training for women with UUI. CONCLUSION: Although almost all studies included reported positive results in favour of physical therapies for the treatment of

UUI, more research of high methodological quality is required to evaluate the effects of each method in the range of physical therapies

Bielefeldt K., Enck P., and Erckenbrecht J.F. (1990) Sensory and motor function in the maintenance of anal continence. *Dis. Colon Rectum* 33, 674-678.

Abstract: Anorectal function was prospectively evaluated in 43 consecutive patients with fecal incontinence and in 19 healthy volunteers using manometry and electrical stimulation of the anoderm. Both anorectal motor and sensory function was impaired in incontinent patients as compared with healthy controls. Further statistical analysis identified four subgroups of patients showing different pathomechanisms of fecal incontinence: severe combined anorectal motor and sensory dysfunction, isolated anal sphincter dysfunction, isolated anorectal sensory dysfunction, and combined dysfunction of the internal anal sphincter and impaired anorectal sensitivity. These data support the hypothesis that sensory function of both the rectum and the anal canal is an important and independent factor in the preservation of continence

Bladou F., Houvenaeghel G., Delpero J.R., Monges G., Serment G., and Guerinel G. (1996) Construction of a urinary sphincter by means of an electrically stimulated striated muscle: experimental procedure and urodynamic results on canine model. *Int. Surg.* 81, 94-98.

Abstract: A canine model of urinary neosphincter using electrically stimulated autologous striated muscle is described. The superior belly of canine sartorius was activated by a pacemaker with an intermittent low frequency stimulation (0.5-1 pulse per sec) during 7 weeks. Then, the muscle graft was passed around the urethra and sutured back on to itself to form a neosphincter. The surgical procedure was easy to perform and with no complication. Urethral pressure profile was performed initially (T0), and when the muscle was in peri-urethral position, before (T1) and during electrical stimulation (T2). The continence parameter readings (maximal urethral closure pressure MUP, functional length FL, continence zone CZ, and continence area CA) increased from T0 to T1, and from T1 to T2. We noted: 1) 28%, 38%, 52%, and 86% increases for the MUP, FL, CZ, and CA respectively from T0 to T1, 2) 10%, 41%, 30%, and 43% increases for MUP, FL, CZ, and CA respectively from T1 to T2. Chronic low frequency stimulation could transform a skeletal fast-twitch type 2 muscle into a slow-twitch fatigue-resistant type 1 muscle. In this study, morphological changes of the stimulated muscle were noted, whereas phenotype was unchanged. This dynamic autologous neosphincter may be a new alternative to the artificial urinary sphincter prosthesis with fewer complications. Further studies are ongoing to evaluate the efficacy of such a neosphincter as continent system for bladder substitution after pelvic exenteration for pelvic cancers

Bo K. and Maanum M. (1996) Does vaginal electrical stimulation cause pelvic floor muscle contraction? A pilot study. *Scand. J. Urol. Nephrol. Suppl* 179, 39-45.

Abstract: The purpose of the present study was to evaluate whether vaginal electrical stimulation using Conmax and Medicon MS-105 causes pelvic floor muscle contraction. In addition, pain and discomfort described by the participants were registered. Nine women, mean age 37.7 years (range 24-54) participated in the study; five healthy physio-therapists and four patients with diagnosed genuine stress incontinence. All the participants used Conmax and Medicon MS-105 with 10, 20 and 50 Hz in random order. The women increased the current step by step to tolerance level. Two physiotherapists were observing the perineum and notified whether a correct contraction was occurring. The participants reported whether there was a

correct contraction of the pelvic floor and described pain and discomfort, classified according to McGill Pain Questionnaire. The results demonstrated that a correct contraction was reported and observed in only one of nine women. Electrical stimulation with all frequencies caused pain and discomfort in all women

- Bo K. and Talseth T. (1997) Change in urethral pressure during voluntary pelvic floor muscle contraction and vaginal electrical stimulation. *Int. Urogynecol. J. Pelvic Floor. Dysfunct.* 8, 3-6.

Abstract: The purpose of the study was to compare the effect of voluntary pelvic floor muscle (FFM) contraction and vaginal electrical stimulation on urethral pressure. Twelve women with genuine stress incontinence, mean age 49.4 years (range 33-66) participated in the study. The urethral and bladder pressures were recorded simultaneously through a double-lumen 8 Ch catheter. The patients first performed three voluntary PFM contractions. Then two electrical stimulators, Conmax and Medicon MS 105, 50 Hz, were used in random order. A visual analog scale was used to measure pain and discomfort. Pain was reported to mean 6.8, SEM 0.64 (range 0.7-9.9) and mean 6.1, SEM 0.81 (range 0-9.1) with Conmax and Medicon MS 105, respectively. The mean paired difference in favor of voluntary contraction with Conmax was -8.0, SD 6.7, $P = 0.0067$, and with Medicon MS 105 it was -12.2, SD 5.9, $P = 0.0022$. The results demonstrated that voluntary PFM contraction increased urethral pressure significantly more than did vaginal electrical stimulation

- Bo K. (1998) Effect of electrical stimulation on stress and urge urinary incontinence.

Clinical outcome and practical recommendations based on randomized controlled trials. *Acta Obstet. Gynecol. Scand. Suppl* 168, 3-11.

Abstract: BACKGROUND: The aim of the present study was to review the literature on randomized controlled trials of electrical stimulation to treat urge and stress urinary incontinence. METHODS: Studies were compiled from Medline from 1980 till 1996 and manual searches of relevant journals. Randomized controlled studies full length published in English, German and Scandinavian languages were included. RESULTS: Nine studies evaluating the effect of electrical stimulation on stress urinary incontinence and one study evaluating the effect of urge incontinence were found. Only three studies had a sufficient sample size to enable conclusion on stress urinary incontinence. Two demonstrated negative, and one positive effect (20% cure and 46% improved measured by pad test). The study on urge incontinence demonstrated that there was no difference in effect after electrical stimulation or anticholinergic drugs. CONCLUSION: The results of randomized controlled trials evaluating the effect of electrical stimulation to treat stress and urge urinary incontinence are conflicting. There is a need for more randomized controlled trials with sufficient sample sizes, use of sensitive, reproducible and valid outcome measures, and optimal stimulation parameters. Based on the present knowledge pelvic floor muscle exercise should be the first choice of treatment for stress urinary incontinence

- Bo K., Talseth T., and Holme I. (1999) Single blind, randomised controlled trial of pelvic floor exercises, electrical stimulation, vaginal cones, and no treatment in management of genuine stress incontinence in women. *BMJ* 318, 487-493.

Abstract: OBJECTIVE: To compare the effect of pelvic floor exercises, electrical stimulation, vaginal cones, and no treatment for genuine stress incontinence. DESIGN: Stratified, single blind, randomised controlled trial. SETTING: Multicentre. PARTICIPANTS: 107 women with clinically and urodynamically proved genuine

stress incontinence. Mean (range) age was 49.5 (24-70) years, and mean (range) duration of symptoms 10.8 (1- 45) years. INTERVENTIONS: Pelvic floor exercise (n=25) comprised 8-12 contractions 3 times a day and exercise in groups with skilled physical therapists once a week. The electrical stimulation group (n=25) used vaginal intermittent stimulation with the MS 106 Twin at 50 Hz 30 minutes a day. The vaginal cones group (n=27) used cones for 20 minutes a day. The untreated control group (n=30) was offered the use of a continence guard. Muscle strength was measured by vaginal squeeze pressure once a month. MAIN OUTCOME MEASURES: Pad test with standardised bladder volume, and self report of severity. RESULTS: Improvement in muscle strength was significantly greater (P=0.03) after pelvic floor exercises (11.0 cm H₂O (95% confidence interval 7.7 to 14.3) before v 19.2 cm H₂O (15.3 to 23.1) after) than either electrical stimulation (14.8 cm H₂O (10. 9 to 18.7) v 18.6 cm H₂O (13.3 to 23.9)) or vaginal cones (11.8 cm H₂O (8.5 to 15.1) v 15.4 cm H₂O (11.1 to 19.7)). Reduction in leakage on pad test was greater in the exercise group (-30.2 g; -43. 3 to 16.9) than in the electrical stimulation group (-7.4 g; -20.9 to 6.1) and the vaginal cones group (-14.7 g; - 27.6 to -1.8). On completion of the trial one participant in the control group, 14 in the pelvic floor exercise group, three in the electrical stimulation group, and two in the vaginal cones group no longer considered themselves as having a problem. Conclusion: Training of the pelvic floor muscles is superior to electrical stimulation and vaginal cones in the treatment of genuine stress incontinence

Bo K. (2000) [Pelvic floor muscle exercise and urinary incontinence--train yourself continent!]. Tidsskr. Nor Laegeforen. 120, 3583-3589.
Abstract: BACKGROUND: Urinary incontinence is a major female health problem with prevalence rates varying between 8% and 52%. Urinary incontinence can be treated with surgery, medication, and several forms of pelvic floor muscle training. The aim of this review article is to evaluate the evidence from randomized controlled trials of pelvic floor muscle training in the treatment of urinary incontinence. MATERIAL AND METHODS: Computerised search in Medline and Sport and manual search in former published systematic reviews were undertaken. Only published articles of randomized controlled trials were included. RESULTS: Several randomized controlled trials have demonstrated that pelvic floor muscle training is more effective than no treatment and electrical stimulation in the treatment of stress incontinence. Adding biofeedback to the training has so far showed no additional effect. There is a lack of published studies on the effect of pelvic floor muscle training in urge incontinence and in men. INTERPRETATION: Female stress urinary incontinence can be effectively treated by pelvic floor muscle exercise; this is suggested as the first choice of treatment. There is a need for randomized controlled trials to evaluate the effect of pelvic floor muscle exercise in prevention of urinary incontinence

Bo K. and Berghmans L.C. (2000) Nonpharmacologic treatments for overactive bladder-pelvic floor exercises. Urology 55, 7-11.
Abstract: The theory behind the use of physical therapies (electrical stimulation or pelvic floor muscle [PFM] training with or without biofeedback) for overactive bladder is to (1) inhibit detrusor muscle contraction by voluntary contraction of the PFMs at the same time as the urge to void; and (2) prevent sudden falls in urethral pressure by a change in PFM morphology, position, and neuromuscular function. Few trials have evaluated the effect of PFM training on symptoms of overactive bladder. Most studies are flawed because they include several diagnoses and treatment modalities

in the same intervention. Because of the lack of evidence, no firm conclusion can be drawn on the effect of PFM exercise on overactive bladder. There are some initially promising results, but there is still a need for high-quality, randomized controlled trials on the effect of PFM training on the inhibition of detrusor contraction in human beings. The efficacy of PFM training in combination with other treatments, such as pharmacotherapy, also requires investigation

Boccon-Gibod L. (1980) [Urinary incontinence following prostatectomy: hopes and disappointments. 42 cases (author's transl)]. *Nouv. Presse Med.* 9, 2339-2342.
Abstract: Between 0,5 and 1% of prostatectomies are complicated by urinary incontinence due to the destruction of both proximal and distal urethral sphincters. Any incontinence persisting more than 12 months after surgery should be considered as permanent. Among all treatments proposed (medical treatment, electrical stimulation of the perineum, various plastic operations and prostheses with varied and numerous materials), only inflatable prostheses seem to give "better than nothing results. The best treatment of post-operative incontinence, however, is preventive: extreme care should be exercised during the enucleation or trans-urethral resection of the adenoma

Bock J.U. and Jongen J. (1996) [Diagnostic and therapeutic procedures in fecal incontinence in general practice of the surgically educated proctologist]. *Zentralbl. Chir* 121, 659-664.
Abstract: Age related, about 10% of the general population suffer from faecal incontinence. In a surgical, proctological office diagnosis is possible with carefully taken history, physical examination, digital examination of the anorectum, rigid rectosigmoidoscopy, and anoscopy. Together with special examinations (endoanal ultrasound, electromyography, pudendal nerve terminal motor latency [PNTML], anorectal manometry, defaecography, transit time of the colon) the plan for medical and surgical treatment can be made. The basic medical conservative therapy consists of regulating the form of stool (high fibre diet and/or loperamid), training of the sphincter and pelvic muscles electrical stimulation or biofeedback training. Outpatient surgery is possible for small prolapsing tumors of the lower rectum or anal canal, hemorrhoids grade 2 or segmental anal prolapse. Inpatient surgery is needed for any form of reconstruction of the sphincter or the sensitive area of the anal canal,

Borrelli M., Alves P.R., Gama A.H., and Goes G.M. (1977) Urinary incontinence: two cases of electronic stimulation after failing the Leadbetter technique. *Urol. Int.* 32, 260-264.
Abstract: Two cases of urinary incontinence treated by electrical stimulation after failing the Leadbetter technique are presented. Both were first seen bearing imperforated anus. They suffered several operations for correcting this pathology and further attempting to relieve complete urinary incontinence. After a trial with intrarectal stimulation one of them received an implant. The other continued to use the anal plug. In both cases the result has been satisfactory. Cine radiological documentation of the sphincteric action of the stimulated muscles was performed

Bosch J.L. and Groen J. (1995) Sacral (S3) segmental nerve stimulation as a treatment for urge incontinence in patients with detrusor instability: results of chronic electrical stimulation using an implantable neural prosthesis. *J. Urol.* 154, 504-507.
Abstract: PURPOSE: We studied the effects of sacral (S3) nerve stimulation in patients with urge incontinence due to detrusor instability. MATERIALS AND

METHODS: A permanent S3 foramen electrode was implanted in 18 patients (average age 46 years) who had shown a good response during temporary stimulation via a percutaneously placed wire electrode. Average followup was 29 months. **RESULTS:** The average voiding frequency and pad use per 24 hours decreased significantly. Improvement in several urodynamic parameters was noted. The correlation between symptomatic and urodynamic improvement was incomplete. **CONCLUSIONS:** Neuromodulation appears to be a valuable treatment option in these patients

Bosch J.L. and Groen J. (2000) Sacral nerve neuromodulation in the treatment of patients with refractory motor urge incontinence: long-term results of a prospective longitudinal study. *J. Urol.* 163, 1219-1222.

Abstract: **PURPOSE:** Conservative treatment rarely results in a durable cure of patients with urge incontinence and bladder overactivity. Instrumental and surgical procedures often have significant side effects and less than optimal results. We developed a technique of sacral nerve neuromodulation using chronic unilateral electrical stimulation of the S3 sacral nerve to inhibit the micturition reflex to provide effective nondestructive alternative therapy for patients whose condition is refractory to conservative treatment. **MATERIALS AND METHODS:** Of 85 patients 45 who responded to a test with a temporary electrode underwent implantation of a permanent S3 sacral nerve electrode coupled to a pulse generator. Treatment results were evaluated by urodynamic studies and voiding/incontinence diaries documenting pad use, incontinence episodes, voiding frequency and voided volume. Partial success and cure were defined as 50% to 90% and more than 90% improvement, respectively, in pad use and/or incontinence episodes. **RESULTS:** Of 45 patients 18 (40%) were cured at an average followup of 47.1 months and 9 (20%) achieved partial success. Median number of pads used and median number of incontinence episodes daily had decreased from 5.4 to 1.2 ($p = 0.0001$) and 7.1 to 1.3 ($p = 0.0001$), respectively, 6 months after implantation. Subsequently these results remained almost constant for 5 years. Bladder overactivity disappeared in 19 of the 44 patients (43%). The repeat intervention rate was 37.7% and there was no permanent injury or nerve damage. **CONCLUSIONS:** Sacral nerve neuromodulation is safe, effective and durable in patients with urge incontinence refractory to conservative treatment

Bouamrène D., Micallef J.P., Rouanet P., and Bacou F. (2000) Electrical stimulation-induced changes in double-wrapped muscles for dynamic graciloplasty. *Arch. Surg.* 135, 1161-1167.

Abstract: **HYPOTHESIS:** Treatment of fecal incontinence has been greatly improved by electrical stimulation of gracilis muscle transposed around the anal canal. Various configurations of the muscle have been used: single alpha, gamma, epsilon muscle loops, split sling, or double wrap. We report herein experimental data on muscle transformation and damage induced by the latter surgical approach. **DESIGN, INTERVENTIONS, AND MAIN OUTCOME MEASURES:** This study was conducted on 4 groups of New Zealand white rabbits. Group 1 had unstimulated transposed gracilis muscles. Group 2 had left transposed gracilis muscles stimulated only. Group 3 had both right and left transposed gracilis muscles stimulated. Group 4 were the controls (not operated on). Muscle properties were studied by electrophysiological, immunohistochemical, and biochemical techniques. **RESULTS:** Transformation from fast-contractile glycolytic muscle fibers into fast-intermediate to slow-contractile oxidative muscle fiber types induced a fatigue resistance of the

transposed muscle that has undergone long-term stimulation and muscle alterations characterized by fiber atrophy and fibrosis. CONCLUSIONS: Whatever technique of dynamic graciloplasty is used, muscle degeneration associated with mobilization might result primarily from the surgical dissection, whereby collateral blood supply to the gracilis is interrupted and exacerbated by long-term stimulation

Bourcier A.P. and Juras J.C. (1995) Nonsurgical therapy for stress incontinence. *Urol. Clin. North Am.* 22, 613-627.

Abstract: This article discusses the therapies that have been developed for the treatment of stress incontinence due to female pelvic-floor dysfunction. A combination of pelvic muscle exercises, biofeedback, behavioral modification, and electrical stimulation are all treatment options that do not involve surgery. When physiotherapy proves successful, and surgery is avoided, it is necessary for the patient to be put on a maintenance program to avoid relapse. The authors also discuss the link between urinary stress incontinence and women involved in sports

Bratt H., Salvesen K.A., Eriksen B.C., and Kulseng-Hanssen S. (1998) Long-term effects ten years after maximal electrostimulation of the pelvic floor in women with unstable detrusor and urge incontinence. *Acta Obstet. Gynecol. Scand. Suppl* 168, 22-24.

Abstract: OBJECTIVE: The purpose was to study any long-term therapeutic effects of maximal electrical stimulation in female urge incontinence. METHODS: A postal questionnaire containing six questions about urinary incontinence was distributed to 30 women who had been treated with maximal stimulation because of unstable detrusor and urge incontinence 9-13 years earlier. The response rate was 90% (27 women). The mean age at follow-up was 62 years. RESULTS: Twenty-one (78%) women reported symptoms of urge incontinence. Among them, 13 had this problem daily, whereas eight only had problems weekly or even more seldom. Nineteen (70%) women reported symptoms of stress incontinence. Twenty-one women would have recommended maximal stimulation to a friend today. CONCLUSION: After approximately ten years most of the women had symptoms of urge incontinence. This was, however, a minor problem among a third of them. A majority of the women were satisfied with maximal stimulation as a treatment modality. The treatment had not prevented a later occurrence of stress incontinence

Brehmer M. and Nilsson B.Y. (2000) Elevation of sensory thresholds in the prostatic urethra after microwave thermotherapy. *BJU. Int.* 86, 427-431.

Abstract: OBJECTIVES: To determine whether transurethral microwave thermotherapy (TUMT) affects the sensory threshold in the posterior urethra and whether such an effect influences urinary storage symptoms. PATIENTS AND METHODS: The sensory threshold was measured before and at 3 and 12 weeks after TUMT in 13 men with minor obstructive symptoms caused by benign prostatic hyperplasia. Sensations were evoked by electrical stimulation at different frequencies, using a bipolar ring-electrode mounted on a urethral catheter. Changes in sensory thresholds were evaluated in the patients both as a group and individually. The patients were interviewed about their symptoms at each measurement. RESULTS: After TUMT, 12 patients were satisfied and reported decreased irritative symptoms, primarily less frequent nocturnal micturition; two patients were cured of urgency incontinence. In 11 of the satisfied patients, and the unsuccessful patient, decreased urge accompanied increased sensory thresholds. Thresholds elevated by $\geq 30\%$ were correlated with decreased irritative symptoms. CONCLUSIONS:

TUMT decreases sensitivity in the posterior urethra, which may alleviate storage symptoms

Brown C. (1998) Pelvic floor rehabilitation: conservative treatment for incontinence. *Ostomy. Wound. Manage.* 44, 72-76.
Abstract: Pelvic floor rehabilitation is used to treat stress urinary incontinence, urge, and fecal incontinence as well as other pelvic floor musculature disorders. When treating patients, it is important to thoroughly assess the pelvic floor. In addition to evaluating the urinary system, sexual and bowel functions must also be considered. Treatment plans should be devised on an individual basis according to the evaluation findings. Rehabilitation goals should be established. The patient must understand the function of her urinary system and the role she must play in its control. Muscle retraining is achieved through a personalized exercise program. This program may be augmented by manual techniques, biofeedback or electrical stimulation. While the Agency for Health Care Policy and Research (AHCPR) does endorse the use of behavioral modalities in treating urinary incontinence, the use of bladder retraining and pelvic floor rehabilitation is not always recommended when indicated, nor accessible for all patients who require it. More research is needed, in addition to ongoing public and professional education on behavioral interventions in order to underline the advantages of this form of treatment for incontinence

Brubaker L., Benson J.T., Bent A., Clark A., and Shott S. (1997) Transvaginal electrical stimulation for female urinary incontinence. *Am. J. Obstet. Gynecol.* 177, 536-540.
Abstract: OBJECTIVE: Our purpose was to determine the objective and subjective efficacy of transvaginal electrical stimulation for treatment of common forms of urinary incontinence in women. STUDY DESIGN: A prospective, double-blind, randomized clinical trial included 121 women with either urinary incontinence caused by detrusor instability or genuine stress incontinence, or both (mixed incontinence). Participants used the assigned device for 8 weeks. Identical preintervention and postintervention assessment included multichannel urodynamic testing, quality-of-life scale, and urinary diaries. RESULTS: A total of 121 women completed this study at four North American urogynecology centers. Detrusor instability was cured (stable on provocative cystometry) in 49% of women with detrusor instability who used an active electrical device ($p = 0.0004$, McNemar's test), whereas there was no statistically significant change in the percentage with detrusor instability in the sham device group. There was no statistically significant difference between the preintervention and postintervention rates of genuine stress incontinence for either the active device group or the sham device group. CONCLUSION: This form of transvaginal electrical stimulation may be effective for treatment of detrusor overactivity, with or without genuine stress incontinence

Brubaker L. (2000) Electrical stimulation in overactive bladder. *Urology* 55, 17-23.
Abstract: Electrical stimulation is an effective and well-tolerated treatment for overactive bladder. Initial work in animals indicated the potential of this treatment, and early clinical experience in Europe further supported its likely efficacy. Although the mechanism of action of electrical stimulation remains unproven in humans, it is believed to be a neuromodulating therapy which affects the neural signaling that controls continence. There is also strong evidence that electrical stimulation affects striated muscle. The therapy can cause hypertrophy of skeletal muscle fibers, possibly by the recruitment of faster-conducting motor units, which would not normally be recruited during voluntary efforts. In addition, electrical stimulation can

alter the expression of myosin isoforms, favoring a conversion to type I muscle. Despite our incomplete understanding of the mechanism of action of electrical stimulation, clinical devices have been developed quickly. Case series have been reported throughout Europe. These were followed by controlled clinical trials in the United States. There is good evidence that the use of vaginal electrical stimulators can reduce the occurrence of symptoms of overactive bladder in about half of the patients treated. Multiple uses of nonimplanted stimulation, including thigh stimulation, anal stimulation, and direct pelvic muscle stimulation, have been reported. In these trials, it is common for objective findings to be poorly correlated with subjective reports of improvements or cure. Patients frequently report that the urge-to-leave time improves, but this is difficult to measure objectively. The use of nonimplanted devices is effective and well tolerated, and should precede the use of implanted devices. A direct comparison with other effective methods of treatment for overactive bladder is warranted

Caldwell K.P. (1968) The use of electrical stimulation in urinary retention and incontinence. *Proc. R. Soc. Med.* 61, 703.

Caldwell K.P., Cook P.J., Flack F.C., and James E.D. (1968) Urethral pressure recordings in male incontinent under electrical stimulation. *Invest Urol.* 5, 572-579.

Caldwell K.P. (1974) Proceedings: Electrical stimulation. *Urol. Int.* 29, 225.

Caputo R.M., Benson J.T., and McClellan E. (1993) Intravaginal maximal electrical stimulation in the treatment of urinary incontinence. *J. Reprod. Med.* 38, 667-671. Abstract: Urinary incontinence imposes a large economic burden, estimated at \$10 billion per year. As the cost of health care continues to rise, conservative therapeutic measures are becoming more attractive. Anecdotal reports suggest that electrical stimulation may be up to 87% effective in the treatment of urinary incontinence. Investigators use different stimulation devices and protocols and make a comparison of results difficult. The true efficacy of electrical stimulation for the treatment of urinary incontinence is unknown since there have been no controlled clinical trials. Within our referral-based urogynecology practice, we employ intermittent, intravaginal maximal electrical stimulation in conjunction with bladder drills and pelvic floor exercises. Over a one-year period we treated 76 women with urinary incontinence: 19 with stress incontinence (SUI), 30 with detrusor instability (DI) and 27 with mixed incontinence (MI). After six weeks, our overall objective improvement rate was 76%; 89% of patients with SUI, 73% with DI and 70% with MI met the criteria for improvement. Long-term follow-up averaged 6 months, with a range of 2-12. Of patients who showed an initial objective improvement, 87% maintained that improvement. Intravaginal electrical stimulation may be effective therapy for urinary incontinence. Controlled clinical trials are needed to determine its efficacy and standardize stimulation protocols before its widespread use

Chancellor M.B., Hong R.D., Rivas D.A., Watanabe T., Crewalk J.A., and Bourgeois I. (1997) Gracilis urethromyoplasty--an autologous urinary sphincter for neurologically impaired patients with stress incontinence. *Spinal Cord.* 35, 546-549.

Abstract: PURPOSE: To investigate the effect of a neurovascularly intact gracilis muscle urethral wrap, to be used to restore urinary continence as a transposed urinary sphincter graft, in patients with neurogenic lower urinary tract dysfunction. METHODS: Five neurologically impaired men with a denervated and damaged

urinary sphincter mechanisms were treated. The etiology of sphincteric insufficiency included sphincter denervation in three patients, external sphincterotomy in one, and urethral trauma due to a chronic indwelling catheter in one. All patients underwent gracilis urethromyoplasty sphincter reconstruction. Two patients also underwent concomitant ileocystoplasty and one patient ileocystostomy because of poor bladder compliance and a bladder capacity of < 200 ml. RESULTS: The gracilis urethromyoplasty functioned as a new autologous sphincter with follow-ups ranging from 6-35 months. The surgery was successful in four patients. Three of the four patients were managed with intermittent catheterization, and one managed by ileocystostomy. The fifth patient continued to require an indwelling urethral catheter. CONCLUSION: Gracilis urethromyoplasty achieves compression of the urethra using a neurovascularly intact muscle graft. The functional urethral closure, obtained from the gracilis muscle wrap, assures dryness, and permits intermittent self-catheterization. It also avoids the risks of infection, erosion, or malfunction associated with the artificial urinary sphincter. The potential exists for electrical stimulation of this muscle graft to allow volitional control of the neo-sphincter mechanism, and voluntary voiding

Chancellor M.B., Heesakkers J.P., and Janknegt R.A. (1997) Gracilis muscle transposition with electrical stimulation for sphincteric incontinence: a new approach. *World J. Urol.* 15, 320-328.

Abstract: Neurovascularly intact gracilis-muscle transposition to the proximal urethra is an exciting new technique for sphincteric incontinence. The functional urethral closure of gracilis myoplasty assures dryness, permits intermittent self-catheterization when necessary, and avoids the risks of erosion associated with the artificial urinary sphincter. Electrical stimulation of the transposed muscle (dynamic urethral myoplasty) using intramuscular electrodes and a subcutaneously placed pulse generator can alter the molecular physiology of the gracilis muscle from that of predominantly fast-twitch to that of slow-twitch fibers that are fatigue-resistant and more suitable for long-term sphincter function

Collins C.D., Brown B.H., and Duthie H.L. (1968) A basis for electrical stimulation for anal continence. *Scand. J. Gastroenterol.* 3, 395-400.

Collins C.D., Brown B.H., and Duthie H.L. (1969) An assessment of intraluminal electrical stimulation for anal incontinence. *Br. J. Surg.* 56, 542-546.

Collins C.D. (1972) Urethral incontinence in women. Observations on the effect of electrical stimulation. *Proc. R. Soc. Med.* 65, 832-833.

Collins C.D. (1974) Proceedings: Intermittent electrical stimulation. *Urol. Int.* 29, 221.

Creasey G.H., Kilgore K.L., Brown-Triolo D.L., Dahlberg J.E., Peckham P.H., and Keith M.W. (2000) Reduction of costs of disability using neuroprostheses. *Assist. Technol.* 12, 67-75.

Abstract: The lifetime costs associated with spinal cord injury are substantial. Assistive technology that reduces complications, increases independence, or decreases the need for attendant services can provide economic as well as medical or functional benefit. This study describes two approaches for estimating the economic consequences of implanted neuroprostheses utilizing functional electrical stimulation. Life care plan analysis was used to estimate the costs of bladder and

bowel care with and without a device restoring bladder and bowel function and to compare these with the costs of implementing the device. For a neuroprosthesis restoring hand grasp, the costs of implementation were compared to the potential savings in attendant care costs that could be achieved by the use of the device. The results indicate that the costs of implementing the bladder and bowel system would be recovered in 5 years, primarily from reduced costs of supplies, medications, and procedures. The costs of the hand grasp neuroprosthesis would be recovered over the lifetime of the user if attendant time was reduced only 2 hours per day and in a shorter time if attendant care was further reduced. Neither analysis includes valuation of the quality of life, which is further enhanced by the neuroprostheses through restoration of greater independence and dignity. Our results demonstrate that implantable neuroprosthetic systems provide good health care value in addition to improved independence for the disabled individual

Dahms S.E. and Tanagho E.A. (1998) The impact of sacral root anatomy on selective electrical stimulation for bladder evacuation. *World J. Urol.* 16, 322-328.
Abstract: Although different structures have been studied with electrostimulation to elicit bladder evacuation, only the sacral root remains feasible for clinical application at present. However, the resultant concomitant contractions of the bladder and sphincteric muscles have been the principal problem over the last few decades. Attempts to identify fibers within the sacral ventral root that innervate the detrusor predominantly have been made by microsurgery alone or in combination with advanced electrical blocking techniques. This article evaluates our past and present efforts to achieve voiding in light of the mixed nature of sacral root anatomy

Davila G.W. (1994) Urinary incontinence in women. How to help patients regain bladder control. *Postgrad. Med.* 96, 103-110.
Abstract: Urinary incontinence can have devastating effects on a woman's social life and physical activities. Simple diagnostic tools, including the Q- tip test and cystometry, can help identify the cause. Many causes are reversible, and an appropriate treatment regimen can bring improvement in or completely restore bladder control. Management options that may help patients avoid surgical intervention include bladder drills, pelvic floor muscle exercises, and functional electrical stimulation. Additional nonsurgical approaches are currently under investigation and should result in more options for treating urinary incontinence in women

Deen K.I., Premaratna R., Fonseka M.M., and De Silva H.J. (1998) The recto-anal inhibitory reflex: abnormal response in diabetics suggests an intrinsic neuroenteropathy. *J. Gastroenterol. Hepatol.* 13, 1107-1110.
Abstract: As electrical stimulation of the rectum has been shown to result in reflex internal sphincter inhibition mediated by intrinsic nerves, we aimed to evaluate the integrity of these nerves in the rectum of diabetic patients. Anal canal pressure, recto-anal inhibitory reflex (RAIR) and continence were evaluated in 30 diabetic patients (male:female 13:17, median age 57 years, range 37-70) and these data were compared with similar data obtained from 22 age- and sex-matched healthy controls (male:female 9:13, median age 51 years, range 19-65 years). Median duration of diabetes was 8 years (range 3-30). Twelve (40%) of the 30 diabetics had impaired continence for gas (n = 12) and liquid faeces (n = 3). None of the controls had incontinence. Median maximum resting anal canal pressure (MRP) was: patients 30 mmHg (range 20-75 mmHg) versus controls 40 mmHg (range 20-105 mmHg, P =

0.61). Median maximum squeeze pressure (MSP) was 65 mmHg (range 30-150 mmHg) in patients versus 84mmHg (range 35-230 mm Hg) in controls (P = 0.59). Median threshold rectal mucosal electrosensation (RMES-T) was 27mA (5- 40 mA) in patients versus 13 mA (5-28 mA) in controls (P = 0.03). Maximum tolerable rectal mucosal electrosensation was 40 mA (20-60) in patients versus 20 mA (10-30), in controls (P = 0.042, all comparisons using the Wilcoxon rank test). Recto-anal inhibitory reflex was present in eight, abnormal in five (one incontinent) and absent in 17 (11 incontinent) diabetics, while it was present in 18 and abnormal in four controls (test of proportion, P = 0.031). Blood glucose in diabetics on the day of the procedure was 98 mg/dL (70-165 mg/dL). Rectal mucosal electrosensitivity and RAIR were impaired in significantly more patients with diabetes than controls, implying impairment of intrinsic neuronal function. The recto-anal inhibitory reflex was either impaired or absent in all diabetic patients with incontinence

Dijkema H.E., Weil E.H., Mijs P.T., and Janknegt R.A. (1993) Neuromodulation of sacral nerves for incontinence and voiding dysfunctions. Clinical results and complications. *Eur. Urol.* 24, 72-76.

Abstract: Neuromodulation of sacral nerves is a new form of treatment for patients with refractory voiding dysfunctions such as incontinence, retention and chronic pelvic pain. Electrical stimulation of S3 activates the pelvic floor and modulates innervation of the bladder, sphincter and pelvic floor, restoring the balance and coordination in sacral reflexes. 19 of 23 patients with an implanted neuroprosthesis for neuromodulation have a more than 50% improvement in their main symptoms after a median follow-up of 12 months. In urge-incontinent patients the number of leakings decreased from 7.4 to 1.5/day, and the functional capacity increased from 135 to 227 ml

Donnelly V.S., O'Herlihy C., Campbell D.M., and O'Connell P.R. (1998) Postpartum fecal incontinence is more common in women with irritable bowel syndrome. *Dis. Colon Rectum* 41, 586-589.

Abstract: **PURPOSE:** Anal sphincter damage can occur during vaginal delivery and may lead to impairment of fecal continence. The aim of this study was to determine the influence of irritable bowel syndrome on symptoms of fecal incontinence following first vaginal delivery. **METHODS:** A prospective, observational study was performed before delivery, six weeks, and six months following delivery in primiparous women. A bowel function questionnaire was completed, and anal vector manometry, mucosal electrosensitivity, pudendal nerve terminal motor latency, and anal endosonography were performed. A total of 208 women were assessed before and after delivery, and 104 primigravid women were studied after delivery only. A total of 34 of 312 (11 percent) had an existing diagnosis of irritable bowel syndrome. **RESULTS:** The prevalence of abnormal manometry or endosonography was similar in women with and without irritable bowel syndrome. However, six weeks after delivery, women with irritable bowel syndrome had a higher incidence of defecatory urgency (64 percent) and loss of control of flatus (35 percent) compared with those without (urgency, 10 percent, P < 0.001; flatus, 13 percent, P = 0.007). The incidence of frank fecal incontinence was similar in the two groups. Women with IBS had increased mucosal sensitivity to electrical stimulation of the upper anal canal both before and after delivery. **CONCLUSION:** Women with IBS are more likely to experience subjective alteration of fecal continence postpartum compared with the healthy primigravid population, but they are not at increased risk of anal sphincter injury

Dorey G. (2000) Male patients with lower urinary tract symptoms. 2: Treatment. *Br. J. Nurs.* 9, 553-558.

Abstract: The first part of this article (Dorey, 2000) described the subjective and objective assessment of men with lower urinary tract symptoms (LUTS). This article will examine treatment protocols for stress incontinence, urge incontinence, post-prostatectomy incontinence, post-micturition dribble, overflow incontinence, reflex incontinence and functional incontinence. Pelvic floor muscle exercises, biofeedback, electrical stimulation, urge suppression techniques, and fluid intake are discussed. It is concluded that men with LUTS can benefit from conservative treatment

Dudognon P., Salle J.Y., Munoz M., Guinvarc'h S., Bouru M., and Labrousse C. (1995) [Rehabilitation of female urinary incontinence]. *Rev. Prat.* 45, 322-327.

Abstract: Perineal rehabilitation is an appropriate alternative to surgery in the treatment of urinary female incontinence. The most important factors influencing the success of this technique is the ability of the patient to identify correctly the muscles of the pelvic floor, to strengthen this muscles using exercises, electrical stimulation and biofeedback, to contract voluntarily the pelvic floor musculature during stress or sensation of voiding for having a preventive effect on loss of urine, and also to change, if necessary, the micturitional and drinking customs. Some conditions are required to complete a good result: strong motivation of the woman, ability of the physiotherapist or the midwife, quality of care and follow-up of the physician who must clearly know the place of this conservative treatment in selected patients, particularly in moderate stress incontinence, without important prolapse, urge incontinence, pregnancy and post-partum, two conditions in which this technique must have a preventive and curative efficiency

Dumoulin C., Seaborne D.E., Quirion-DeGirardi C., and Sullivan S.J. (1995) Pelvic-floor rehabilitation, Part 1: Comparison of two surface electrode placements during stimulation of the pelvic-floor musculature in women who are continent using bipolar interferential currents. *Phys. Ther.* 75, 1067-1074.

Abstract: **BACKGROUND AND PURPOSE:** Electrical stimulation of the pelvic floor is used as an adjunct in the conservative treatment of urinary incontinence. No consensus exists, however, regarding electrode placements for optimal stimulation of the pelvic-floor musculature. The purpose of this study was to compare two different bipolar electrode placements, one suggested by Laycock and Green (L2) the other by Dumoulin (D2), during electrical stimulation with interferential currents of the pelvic-floor musculature in continent women, using a two-group crossover design. **SUBJECTS:** Ten continent female volunteers, ranging in age from 20 to 39 years (mean = 27.3, SD = 5.6), were randomly assigned to one of two study groups. **METHODS:** Each study group received neuromuscular electrical stimulation (NMES) of the pelvic-floor musculature using both electrode placements, the order of application being reversed for each group. Force of contraction was measured as pressure (in centimeters of water [cm H₂O]) exerted on a vaginal pressure probe attached to a manometer. Data were analyzed using a two-way, mixed-model analysis of variance. **RESULTS:** No difference in pressure was observed between the two electrode placements. Differences in current amplitude were observed, with the D2 electrode placement requiring less current amplitude to produce a maximum recorded pressure on the manometer. Subjective assessment by the subjects revealed a preference for the D2 electrode placement (7 of 10 subjects). **CONCLUSION AND DISCUSSION:** The lower current amplitudes required with the D2 placement to obtain recordings comparable to those obtained with the L2

technique suggest a more comfortable stimulation of the pelvic-floor muscles. The lower current amplitudes required also suggest that greater increases in pressure might be obtained with the D2 placement by increasing the current amplitude while remaining within the comfort threshold. These results will help to define treatment guidelines for a planned clinical study investigating the effects of NMES and exercise in the treatment of urinary stress incontinence in women postpartum. [Dumoulin C, Seaborne DE, Quirion-DeGirardi C, Sullivan SJ. Pelvic-floor rehabilitation, part 1: comparison of two surface electrode placements during stimulation of the pelvic-floor musculature in women who are continent using bipolar interferential currents

Duthie H.L. (1968) The use of intermittent electrical stimulation in anal incontinence. Proc. R. Soc. Med. 61, 706-707.

Eckstein H.B. (1975) Treatment of incontinence by electrical stimulation. Nurs. Times 71, 1423-1424.

Egon G., Barat M., Colombel P., Visentin C., Isambert J.L., and Guerin J. (1998) Implantation of anterior sacral root stimulators combined with posterior sacral rhizotomy in spinal injury patients. World J. Urol. 16, 342-349.
Abstract: Brindley-Finotech sacral anterior root stimulators combined with posterior sacral rhizotomy were implanted in 68 males and 28 females with spinal cord lesions. In 9 patients the electrodes were implanted extradurally in the sacrum, and in 90 patients they were implanted intradurally (3 patients had a second extradural implant after a first intradural implant). Three patients died from causes unrelated to the implant. Of the 93 surviving patients, 83 used their implants for micturition and 82 were fully continent. The mean bladder capacity increased from 206 ml preoperatively to 564 ml after the operation. Three patients had a preoperative vesicorenal reflux that disappeared after surgery. In all, 51 patients used the stimulator for defecation. Erection was possible with electrical stimulation in 46 males and was used for coitus by 17 couples. Secondary deafferentation at the level of the conus was performed four times. Three patients who had a cerebrospinal fluid leak were operated on again. Two implants had to be removed because of infection. Sacral anterior root stimulation combined with sacral deafferentation is a welcome addition to the treatment of neurogenic bladder in spinal cord injury patients

Erlandson B.E., Fall M., Carlsson C.A., and Linder L.E. (1977) Mechanisms for closure of the human urethra during intravaginal electrical stimulation. Scand. J. Urol. Nephrol. Suppl 49-54.

Abstract: The effect of intravaginal electrical stimulation (IVS) on the urethral pressure profile (UPP) before and during succinylcholine blockade or spinal anaesthesia was studied in patients with stress incontinence and in patients with clinically normal urethral function. During succinylcholine blockade, the UPP was lowered to 74% and during spinal anaesthesia to 39% of the original maximal UPP. IVS could not influence the UPP during succinylcholine blockade, while the UPP could be restored during spinal anaesthesia when the stimulation strength was increased 3 to 4 times. The following conclusions were arrived at: 1) The urethral effect of IVS is due to activation of somatic nerves and not to activation of nerves supplying smooth muscles or direct activation of striated and smooth muscles. 2) The more pronounced depression of the UPP during spinal anaesthesia compared to succinylcholine blockade should be caused by the loss of nervous activity of the smooth muscles. 3) The fact that the UPP could be restored during spinal

anaesthesia indicates that activation of somatic efferents can compensate for the loss of striated and smooth muscle activity. Therefore, IVS can control incontinence in partial lower motor neuron lesions, provided a sufficient number of efferent neurons are preserved

Erlandson B.E., Fall M., and Carlsson C.A. (1977) The effect of intravaginal electrical stimulation on the feline urethra and urinary bladder. Electrical parameters. Scand. J. Urol. Nephrol. Suppl 5-18.

Abstract: Intravaginal electrical stimulation (IVS) in cats caused urethral closure and bladder inhibition. The aim was to ascertain the electrical parameters most appropriate for these effects. Minimum voltage was used as main criterion to select an effective, non-destructive stimulation when the shape, frequency and duration of the pulses were systematically varied. Urethral closure was achieved at minimum voltage (3 V) with alternating pulses at a frequency of 50 Hz and a pulse duration of 1.5 ms. Corresponding optimal parameters for bladder inhibition were: alternating pulses, 10 Hz and 1.5 ms. Minimum voltage was 1 V. Moreover, the positions of the electrodes were of significance for the responses. The clinical implications of these findings are that: 1) more differentiated treatment of incontinence could be achieved by adapting the stimulation parameters to the cause of incontinence, and 2) specific electrode positions would probably give optimal responses

Erlandson B.E., Fall M., and Sundin T. (1977) Intravaginal electrical stimulation. Clinical experiments of urethral closure. Scand. J. Urol. Nephrol. Suppl 31-39.

Abstract: The effect on the urethra of intravaginal electrical stimulation (IVS) was registered by means of urethral pressure profiles (UPP). With the object of finding the most appropriate electrical parameters and optimal electrode positions within the vagina, 24 patients with stress incontinence, 22 with urgency and 4 continent women were studied. Electrical stimulation was given via an obturator with seven electrodes, which could be connected in different combinations of pairs. In all the women, stimulation with the electrodes in specific positions effected a more marked rise in the UPPs than with the electrodes in other positions. A change in position of more than 5 to 10 mm caused a decrease in the response. It was determined that a frequency of between 20 to 50 Hz with a pulse duration of 1 to 5 ms was most effective for urethral closure

Esa A., Kiwamoto H., Sugiyama T., Park Y.C., Kaneko S., and Kurita T. (1991) Functional electrical stimulation in the management of incontinence: studies of urodynamics. Int. Urol. Nephrol. 23, 135-141.

Abstract: Intermittent functional electrical stimulation (FES) was employed for the control of incontinence. One FES session lasted for 30 minutes. It was repeated at intervals of 3 days to 1 week via an anal plug electrode. The success rate was 64% in 41 patients with pollakiuria, urgency and/or urge incontinence, and 43% in 7 patients with stress incontinence. Detrusor activity measured by cystometry did not correlate significantly with the effect on subjective symptoms and the urethral pressure did not increase. The remarkable clinical effect was observed in patients with overactive detrusor function. It seems that FES indirectly inhibits detrusor contraction by suppressing the intrasacral pathway for detrusor activity

Fall M., Erlandson B.E., Sundin T., and Waagstein F. (1977) Intravaginal electrical stimulation. Clinical experiments on bladder inhibition. Scand. J. Urol. Nephrol. Suppl 41-47.

Abstract: The effect of intravaginal electrical stimulation (IVS) on the bladder in 17 patients with motor detrusor instability was explored. Isotonic volume registrations and cystometries were used for evaluation of volume increase and inhibition of abortive detrusor contractions. With either one or the other method, bladder inhibition was found in all patients, but with both methods only in 6. During isotonic volume registration, the volume increase showed considerable variations ranging between 4 to 465%, and during cystometry between 11 to 3500%. Bladder inhibition proved to be most effective when using a frequency of 10 Hz

Fall M., Erlandson B.E., Nilson A.E., and Sundin T. (1977) Long-term intravaginal electrical stimulation in urge and stress incontinence. *Scand. J. Urol. Nephrol. Suppl* 55-63.

Abstract: Using a new device for intravaginal electrical stimulation (IVS), 24 women with pure stress incontinence, mixed urge and stress incontinence or urge incontinence due to detrusor instability, were treated. To minimize mechanical discomfort, the electrode carrier was made of flexible material and inflatable. Furthermore, this design facilitated fixed, constant positioning of the electrodes at individually tested sites to produce maximum response at voltage well tolerated by the patient. The stimulation frequency was adjusted to suit the cause of incontinence: 20 to 50 Hz in stress incontinence, 10 Hz detrusor instability. The electrode carrier was well accepted. Seven of the 9 patients with pure stress incontinence became continent during IVS. Three of them have so far remained continent for 2 to 8 months without IVS. The 15 patients with detrusor instability or mixed incontinence were all free from symptoms after IVS for more than 3 months. Two of them have remained cured for more than 3 months after they had stopped IVS

Fall M., Erlandson B.E., Carlsson C.A., and Sundin T. (1978) Effects of electrical intravaginal stimulation on bladder volume: an experimental and clinical study. *Urol. Int.* 33, 440-442.

Abstract: Clinical observations have indicated that not only stress incontinence due to defective urethral closure but also urge incontinence due to bladder hyperactivity can be successfully treated by electrical stimulation of the pelvic floor. Clinical investigations revealed that intravaginal electrical stimulation caused bladder inhibition registered as a volume increase. This inhibition was most marked at a low stimulation frequency (10 Hz). Animal experiments indicated that the bladder inhibition was achieved by autonomic spinal reflex mechanisms activated by stimulation of pudendal afferents

Fall M. (1984) Does electrostimulation cure urinary incontinence? *J. Urol.* 131, 664-667.

Abstract: A followup study is presented of a prospective series of women treated with an inflatable intravaginal electrode carrier and an external pulse generator. The devices were individually adjustable with respect to electrode positioning and stimulation parameters. The study included 40 women with detrusor instability and/or genuine stress incontinence. The primary results for urge symptoms were favorable. Of the patients 73 per cent were primarily free of symptoms during treatment and 45 per cent remained free of symptoms after withdrawal of treatment, including two-thirds in whom re-education persisted during the followup of 6 years. Of the patients with genuine stress incontinence 40 per cent exhibited persistent re-education. There were considerable discrepancies between symptomatic cure or improvement, and the urodynamic findings at followup. Intravaginal electrical stimulation may be regarded as the treatment of choice for urge incontinence due to detrusor instability,

and in mixed stress and urge incontinence. The method also is an alternative to an operation in some women with genuine stress incontinence

Fall M., Ahlstrom K., Carlsson C.A., Ek A., Erlandson B.E., Frankenberg S., and Mattiasson A. (1986) Contelle: pelvic floor stimulator for female stress-urge incontinence. A multicenter study. *Urology* 27, 282-287.

Abstract: The clinical efficacy of a new device for treatment of female incontinence was studied in a multicenter trial. The device consists of an inflatable electrode carrier and an external stimulator unit. Forty women were treated: 10 had primary or recurrent genuine stress incontinence, 15 had urge incontinence due to idiopathic detrusor instability, not responding to drug treatment, and 15 had stress incontinence combined with detrusor instability. Twenty-five patients were improved by the treatment. Another 8 reported an excellent result of treatment and remained free of symptoms for more than six months after withdrawal of the treatment. The results were more favorable in patients with bladder hyperactivity than in genuine stress incontinence. The patients' general ratings of treatment efficacy correlated well with their recordings of urinary frequency and consumption of incontinence pads. The functional bladder capacity increased in improved patients, but normalization of urodynamic parameters was no prerequisite for clinical improvement. We found intravaginal electrical stimulation to be a valuable alternative to medical and surgical intervention in patients with detrusor instability

Fall M. and Lindstrom S. (1991) Electrical stimulation. A physiologic approach to the treatment of urinary incontinence. *Urol. Clin. North Am.* 18, 393-407.

Abstract: Appropriate management of patients with urinary incontinence requires access to a variety of methods. Electrical stimulation, although so far proportionally small in the armamentarium of methods, is founded on physiologic principles and has the advantage of being curative without significant side effects

Fall M. (1998) Advantages and pitfalls of functional electrical stimulation. *Acta Obstet. Gynecol. Scand. Suppl* 168, 16-21.

Abstract: Functional electrical stimulation has many theoretical advantages. In clinical practice, very favorable results have been repeatedly presented. The experience now encompasses thirty years and a very large number of incontinent patients. Although the methods are widely used, they are differently appreciated. Problems include the fact that functional electrical stimulation does not belong to the therapeutic traditions in urology and gynecology, there is a need of personal training for successful treatment and there is a lack of systematic studies on different clinical applications. Significant advantages are a rational physiological basis, applicability in a variety of lower urinary tract dysfunctions, few side effects and a potential curative effect

Flack F.C. (1968) The use of electrical stimulation in urinary retention and incontinence. *Proc. R. Soc. Med.* 61, 704.

Flannery J.F., Ellis F.G., and Lale P.G. (1969) Electrical stimulation of the striated urinary sphincter mechanism. *Br. J. Surg.* 56, 632.

Formal C.S., Cawley M.F., and Stiens S.A. (1997) Spinal cord injury rehabilitation. 3. Functional outcomes. *Arch. Phys. Med. Rehabil.* 78, S59-S64.

Abstract: This self-directed learning module highlights new advances in this topic

area. It is part of the chapter on spinal cord injury rehabilitation in the Self-Directed Physiatric Education Program for practitioners and trainees in physical medicine and rehabilitation. This article contains information about mobility, ambulation, upper extremity function, bowel management, and technology to enhance function in the community. New advances covered in this section include functional electrical stimulation for enhancing mobility and upper extremity function

Fossberg E., Sorensen S., Ruutu M., Bakke A., Stien R., Henriksson L., and Kinn A.C. (1990) Maximal electrical stimulation in the treatment of unstable detrusor and urge incontinence. *Eur. Urol.* 18, 120-123.

Abstract: Ninety-one patients with unstable detrusor and urge incontinence were treated with maximal electrical stimulation. There were 17 dropouts. From the remaining 74 patients 51 were subjectively cured or significantly improved, this effect lasted for more than 6 weeks in 40. Objectively a significant decrease in frequency was found, also a significant increase in bladder volume. No effect on detrusor pressure at bladder contraction was noted

Geirsson G. and Fall M. (1997) Maximal functional electrical stimulation in routine practice. *Neurourol. Urodyn.* 16, 559-565.

Abstract: Maximal functional electrical stimulation is now an established treatment for urgency and urge incontinence. Many studies have been presented with good and consistent results. In a number of prospective studies we have previously recorded very favourable effects in stress incontinence and urge incontinence. In the present study, we have compared our previous experience with a retrospective analysis of a series of maximal functional electrical stimulation given according to a simple routine protocol and including 84 patients. The overall subjective improvement rate was 54% but the cure rate was only 5%, which is far below our experience in previous studies, as well as in others. The subjective outcome was in agreement with changes in micrurition variables as recorded in voiding diaries. The discrepancy probably depends on a number of factors. It is suggested that the most crucial ones are patient selection, the intensity of stimulation, and the number of sessions given. It is important to realize the limitations and pitfalls of the technique when it is applied in routine practice

George B.D., Williams N.S., Patel J., Swash M., and Watkins E.S. (1993) Physiological and histochemical adaptation of the electrically stimulated gracilis muscle to neoanal sphincter function. *Br. J. Surg.* 80, 1342-1346.

Abstract: The physiological and histochemical characteristics of the gracilis muscle were studied in 19 patients undergoing electrically stimulated gracilis neosphincter construction. Indications for surgery were faecal incontinence (n = 11) and reconstruction following sphincter excision or congenital absence (n = 8). Transposition of the gracilis muscle around the anal canal followed by chronic low-frequency electrical stimulation was associated with a shift in the frequency-response curve and a prolongation of the time-course of individual muscle twitches suggestive of transformation to a slow-twitch fatigue-resistant type. Temporary cessation of electrical stimulation resulted in a reversal of the frequency-response changes. Muscle biopsies taken before and a median of 80 (range 49-137) days after transposition and low-frequency electrical stimulation indicated a significant increase in the proportion of type 1 fibres and a significant decrease in their diameter. These results show that the human gracilis muscle is capable of physiological and histochemical adaptation to long-term neosphincter function

Gladh G., Mattsson S., and Lindstrom S. (2001) Anogenital electrical stimulation as treatment of urge incontinence in children. *BJU. Int.* 87, 366-371.
Abstract: OBJECTIVES: To evaluate retrospectively the result of anogenital afferent stimulation (AGAS) in neurological healthy children with therapy-resistant urge incontinence. PATIENTS AND METHODS: The study included 48 children (24 girls and 24 boys, 5-14 years old) with a diagnosis of bladder instability verified by cystometry in all. Anogenital afferent stimulations were applied using a battery-powered dual constant-current stimulator. The children were stimulated continuously at 10 Hz for 20 min once or twice daily and if required the children and/or the parents continued to apply the treatment at home. For home stimulation a single (anal) channel stimulator was used. The patients were instructed to stimulate for 20 min at maximum intensity two to three times a week until the effects were optimal. The outcome was evaluated retrospectively by comparing voiding/incontinence diaries obtained before and at the follow-up 6-12 months after the end of treatment. RESULTS: AGAS was applied at the clinic for a median (range) of 9 (4-20) times. Thirty-one children continued with home stimulation for another 25 (5-96) sessions. At the follow-up, 18 children were cured and another seven improved, with a leakage score of less than half that before treatment. The treatment was well tolerated by most children. CONCLUSIONS: Anogenital afferent stimulation is an effective, potentially curative treatment in children with severe urge incontinence. Home stimulation is a well accepted adjuvant to treatment at the clinic and improves the outcome

Godec C., Cass A.S., and Ayala G.F. (1975) Bladder inhibition with functional electrical stimulation. *Urology* 6, 663-666.
Abstract: Spastic or hyperreflex bladder dysfunction can cause frequency, urgency, and incontinence. Detrusor activity was inhibited by FES (functional electrical stimulation) applied to the anal sphincter causing decreased bladder spasticity and increased bladder capacity. FES is indicated for incontinence not only because of weakness of the pelvic floor but also because of hyperreflex bladder

Godec C. and Kralj B. (1976) Selection of patients with urinary incontinence for application of functional electrical stimulation. *Urol. Int.* 31, 124-128.
Abstract: Contradictory data from the literature along with our own experience using functional electrical stimulation (FES) have facilitated the determination of objective criteria for the application of FES in correcting urinary incontinence. Simultaneous urodynamic, neurophysiological, and radiological examinations employed during our studies enabled us to determine changes in these parameters due to FES. Among a large number of patients with urinary incontinence (for example: paraplegics, patients with spina bifida, stress incontinence following prostate operations, or resistant enuresis) we have determined that FES is appropriate if applied to properly selected patients. FES is indicated on the basis of the following criteria: the degree of morphological lesion of the urinary tract, the peripheral denervation of the muscles of the pelvic floor, the condition of the spinal center for miction, and, above all the quality of response to FES. FES not only activates the closing muscles of the bladder, but also inhibits the reflex contractions of the detrusor. Here, it should be noted that FES is indicated for cases of reflex incontinence. During FES of the pelvic floor muscles intravesical pressure normally diminishes and the reflex contractions of the detrusor subside. Sometimes, however, the reflex of miction occurs. In such a case, two reflex mechanisms are engaged. Their equilibrium, i.e. controlled miction, can be achieved with an afferent in flow which inhibits the reflex of miction. The use

of FES for the correction of urinary incontinence can be a very good method if the FES parameters are individually chosen and patients properly selected

- Godec C., Cass A.S., and Ayala G.F. (1976) Electrical stimulation for incontinence. Technique, selection, and results. *Urology* 7, 388-397.
Abstract: Incontinence due to hyperreflexic bladder and/or pelvic floor weakness can be corrected by chronic functional electrical stimulation (FES). Cystometry, electromyography of pelvic floor muscles, and anal sphincter pressure measurements with and without electrical stimulation determines if chronic FES will be successful. Post-acute stimulation improvement occurred in patients with incontinence due to hyperreflexic bladder and/or pelvic floor weakness. A success rate of 92 per cent was achieved with chronic FES in incontinent patients with this method of selection
- Godec C., Ayala G., and Cass A. (1977) Electrical stimulation of the rectal ampulla causing reflex voiding. *J. Urol.* 117, 770-772.
Abstract: Electrical stimulation of the rectal ampulla resulted in a desire to void and defecate in 11 patients with an intact nervous system. There was a contraction of the detrusor and the rectal ampulla with relaxation of the anal sphincter. Electrical stimulation of the rectal ampulla and anal sphincter has clinical applications in patients with incontinence of, or inability to empty, the lower urinary tract or fecal system
- Godec C. and Cass A. (1978) Acute electrical stimulation for urinary incontinence. *Urology* 12, 340-341.
Abstract: Acute or maximal electric stimulation of the pelvic floor muscles has been used in incontinent patients who are suitable candidates for electrical stimulation, but unwilling or unable to use the anal plug electrodes. Seventeen of 20 patients had relief or improvement of their incontinence. However 5 of these 17 patients had a relapse of symptoms on follow-up, requiring a repeat treatment with acute or maximal electrical stimulation
- Godec C. and Cass A.S. (1978) Electrical stimulation in the management of incontinence in children. *Minn. Med.* 61, 157-160.
- Godec C. and Cass A.S. (1979) Electrical stimulation for voiding dysfunction after spinal cord injury. *J. Urol.* 121, 73-75.
Abstract: Incontinence and frequency of voiding were present after spinal cord injuries in 18 patients. A hyperreflexic bladder and/or pelvic floor weakness was found in these patients. Functional electrical stimulation resulted in relief or improvement of symptoms in 9 of the 11 patients in whom this procedure was used. An increase in anal sphincter pressure with functional electrical stimulation was a more reliable criterion than an increase in maximum urethral pressure in the selection of patients for the procedure
- Godec C.J. and Cass A.S. (1978) Electrical stimulation for incontinence in myelomeningocele. *J. Urol.* 120, 729-731.
Abstract: Urinary incontinence is the most obvious urinary tract complication in children with myelomeningocele. Incontinence is owing to a hyperreflexic (spastic) bladder and/or pelvic floor weakness, which responds to functional electrical stimulation. Of 33 incontinent children the criteria for functional electrical stimulation

were absent in 21 because of denervation of the pelvic floor muscles. Of 6 children who used functional electrical stimulation 5 had a successful result. However, incontinence recurred in 3 of the 5 patients between 6 and 18 months after functional electrical stimulation treatment was completed and they are awaiting repeat treatment

Godéc C.J., Fravel R., and Cass A.S. (1981) Optimal parameters of electrical stimulation in the treatment of urinary incontinence. *Invest Urol.* 18, 239-241.

Abstract: We evaluated five types of electrical stimulation (continuous, intermittent pseudorandomized, randomized (stochastic), and intermittent randomized) for their effects on muscle contraction and muscle fatigue in 12 patients with urinary incontinence. Continuous stimulation, used in the available commercial stimulators, was not optimal. Randomized (stochastic) stimulation seems to be optimal although this conclusion was not statistically confirmed

Gonzalez-Chamorro F., Verdu T.F., and Hernandez F.C. (1997) [Current status of neurostimulation and neuromodulation for vesicourethral dysfunction]. *Arch. Esp. Urol.* 50, 687-694.

Abstract: OBJECTIVE: To describe the current indications, techniques and results of sacral root stimulation in patients with spinal cord lesions as a treatment for patients with high pressure bladders and/or urinary incontinence despite conservative management, as well as sacral root neuromodulation with permanent stimulators for complex bladder dysfunction: vesical instability, sensory urgency, chronic pelvic pain and chronic voiding dysfunction. METHODS/RESULTS: The literature is reviewed, both techniques are described and the results of the most significant series are discussed, with special reference to the first groups that utilized these techniques. CONCLUSIONS: There is ample experience in the application of sacral root electrical stimulation. The reported results are comparable with those achieved by other treatments, such as augmentation cystoplasty. Neurostimulation and neuromodulation techniques are simple, the complications are minimal and they do not preclude the use of other therapies

Gonzalez-Chamorro F., Esteban F.M., Tamayo Ruiz J.C., Angulo C.J., and Sanchez-Chapado M. (1998) [Electric stimulation of sacral roots for the treatment of urinary incontinence due to detrusor instability: application of a technique and results in a clinical case]. *Arch. Esp. Urol.* 51, 278-283.

Abstract: OBJECTIVE: To describe a case treated with a new technique in our therapeutic algorithm for non-neurogenic vesicourethral dysfunction. METHODS/RESULTS: A 47-year-old female underwent retropubic urethropexy for stress urinary incontinence. She remained incontinent due to detrusor instability to a degree that was socially unacceptable. After conservative treatment had failed, a percutaneous electrode was applied to the sacral nerve root and she received electrical stimulation of 4-6 milliamperes, 15 Hz and 200 microseconds duration for 7 days. Incontinence remitted for as long as 3 months after the electrode had been removed. CONCLUSION: The results achieved with sacral nerve electrical stimulation reported in the literature and our results support the use of this technique in urological clinical practice

Grandjean P., Acker M., Madoff R., Williams N.S., Woloszko J., and Kantor C. (1996) Dynamic myoplasty: surgical transfer and stimulation of skeletal muscle for functional substitution or enhancement. *J. Rehabil. Res. Dev.* 33, 133-144.

Abstract: Dynamic myoplasty combines muscle transfer with electrical stimulation to provide contractile function that augments or replaces impaired organ function. Dynamic cardiomyoplasty was the first clinical application in which a skeletal muscle, latissimus dorsi, was transferred and stimulated to provide cardiac assistance, a function different from its original one. The problem of early muscle fatigue that was encountered in the initial implementation of the method was solved by training the muscle with electrical stimulation and thus changing its fiber composition. With intramuscular electrodes, the conditioned latissimus dorsi is stimulated in synchrony with the heart muscle. Safeguards are built into the two-channel implanted stimulator to avoid excessively high pulse rates. Clinicians report that 80% of patients with moderate to severe heart failure prior to operation showed a clinical improvement of 1.6 New York Heart Association classes. Alternative methods of providing cardiac assistance that are also being investigated include wrapping the muscle around the aorta, creating a skeletal muscle ventricle, and using the muscle to power an implantable pump. These latter techniques are still under preclinical investigation. Compared with heart transplant, cardiomyoplasty has the great advantage of not being subject to tissue rejection. The second principal application of dynamic myoplasty is treatment of fecal incontinence through creation of an electrically stimulated skeletal muscle neosphincter (ESMNS). The gracilis muscle of the leg is mobilized, wrapped around the anal canal, and conditioned with electrical stimulation to become more fatigue resistant. To achieve continence, the muscle is continuously stimulated except when the patient wishes to defecate. Overall success rates in achieving continence are 60-65%. Both cardiomyoplasty and the ESMNS technique, and their associated devices, are being refined through ongoing clinical trials

Halverstadt D.B. (1971) Electrical stimulation of the human bladder: 3 years later. *J. Urol.* 106, 673-677.

Hay-Smith E.J., Bo K., Berghmans L.C., Hendriks H.J., de Bie R.A., and van W. (2001) Pelvic floor muscle training for urinary incontinence in women (Cochrane Review). *Cochrane. Database. Syst. Rev.* 1, CD001407.

Abstract: BACKGROUND: Pelvic floor muscle training is the most commonly recommended physical therapy treatment for women with stress leakage of urine. It is also used in the treatment of women with mixed incontinence, and less commonly for urge incontinence. Adjuncts, such as biofeedback or electrical stimulation, are also commonly used with pelvic floor muscle training. The content of pelvic floor muscle training programmes is highly variable. OBJECTIVES: To determine the effects of pelvic floor muscle training for women with symptoms or urodynamic diagnoses of stress, urge and mixed incontinence, in comparison to no treatment or other treatment options. SEARCH STRATEGY: Search strategy: We searched the Cochrane Incontinence Group trials register (May 2000), Medline (1980 to 1998), Embase (1980 to 1998), the database of the Dutch National Institute of Allied Health Professions (to 1998), the database of the Cochrane Rehabilitation and Related Therapies Field (to 1998), Physiotherapy Index (to 1998) and the reference lists of relevant articles. We handsearched the proceedings of the International Continence Society (1980 to 2000). We contacted investigators in the field to locate studies. Date of the most recent searches: May 2000. SELECTION CRITERIA: Randomised trials in women with symptoms or urodynamic diagnoses of stress, urge or mixed incontinence that included pelvic floor muscle training in at least one arm of the trial. DATA COLLECTION AND ANALYSIS: Two reviewers assessed all trials for inclusion/exclusion and methodological quality. Data were extracted by the lead

reviewer onto a standard form and cross checked by another. Disagreements were resolved by discussion. Data were processed as described in the Cochrane Handbook. Sensitivity analysis on the basis of diagnosis was planned and undertaken where appropriate. MAIN RESULTS: Forty-three trials met the inclusion criteria. The primary or only reference for 15 of these was a conference abstract. The pelvic floor muscle training programs, and comparison interventions, varied markedly. Outcome measures differed between trials, and methods of data reporting varied, making the data difficult to combine. Many of the trials were small. Allocation concealment was adequate in five trials, and nine trials used assessors masked to group allocation. Thirteen trials reported that there were no losses to follow up, seven trials had dropout rates of less than 10%, but in the remaining trials the proportion of dropouts ranged from 12% to 41%. Pelvic floor muscle training was better than no treatment or placebo treatments for women with stress or mixed incontinence. 'Intensive' appeared to be better than 'standard' pelvic floor muscle training. PFMT may be more effective than some types of electrical stimulation but there were problems in combining the data from these trials. There is insufficient evidence to determine if pelvic floor muscle training is better or worse than other treatments. The effect of adding pelvic floor muscle training to other treatments (e.g. electrical stimulation, behavioural training) is not clear due to the limited amount of evidence available. Evidence of the effect of adding other adjunctive treatments to PFMT (e.g. vaginal cones, intravaginal resistance) is equally limited. The effectiveness of biofeedback assisted PFMT is not clear, but on the basis of the evidence available there did not appear to be any benefit over PFMT alone at post treatment assessment. Long-term outcomes of pelvic floor muscle training are unclear. Side effects of pelvic floor muscle training were uncommon and reversible. A number of the formal comparisons should be viewed with caution due to statistical heterogeneity, lack of statistical independence, and the possibility of spurious confidence intervals in some instances. REVIEWER'S CONCLUSIONS: Pelvic floor muscle training appeared to be an effective treatment for adult women with stress or mixed incontinence. Pelvic floor muscle training was better than no treatment or placebo treatments. The limitations of the evidence available mean that it is difficult to judge if pelvic floor muscle training was better or worse than other treatments. Most trials to date have studied the effect of treatment in younger, premenopausal women. The role of pelvic floor muscle training for women with urge incontinence alone remains unclear. Many of the trials were small with poor reporting of allocation concealment and masking of outcome assessors. In addition there was a lack of consistency in the choice and reporting of outcome measures that made data difficult to combine. Methodological problems limit the confidence that can be placed in the findings of the review. Further, large, high quality trials are necessary

Henry M.M. (1994) The role of pudendal nerve innervation in female pelvic floor function. *Curr. Opin. Obstet. Gynecol.* 6, 324-325.

Abstract: The assessment of motor conduction along the pudendal nerve is an accurate objective measure of pudendal nerve function. Measurement of its latency (that is the time interval between electrical stimulation of the nerve and induced contraction of the external anal sphincter) has been demonstrated to be abnormally long following vaginal delivery, particularly if the delivery was associated with a heavy fetus or a prolonged second stage of labor. The significance of pudendal neuropathy and its relationship to abnormal degrees of descent of the pelvic floor have also been examined in this review

Herold A., Bruch H.P., Hocht B., and Muller G. (1989) [Biofeedback training and functional electrostimulation for improving incontinence in children with anal atresia]. *Langenbecks Arch. Chir Suppl II Verh. Dtsch. Ges. Chir* 991-995.
Abstract: Eleven children with anal incontinence following a pull-through operation for anorectal agenesis (4 low, 7 high anomalies) were treated with a conservative continence training program (optic/acoustic biofeedback, transcutaneous electrical stimulation, physical therapy, contraction exercises and sensibility training). All patients with one exception showed subjective and objective improvement of continence. Sphincter contraction increased by 80% in high and by 40% in low anomalies. For a short time electrostimulation provided an improvement of up to 20% in sphincter pressure. One additional success was improved coordination. Beside surgical therapy and other methods continence training is always indicated

Hofbauer J., Preisinger F., and Nurnberger N. (1990) [The value of physical therapy in genuine female stress incontinence]. *Z. Urol. Nephrol.* 83, 249-254.
Abstract: In a prospective randomized study the efficiency of physical therapy in female stress incontinence could be verified. The greatest success rate was achieved by medical gymnastics, whereas the perineal electrical stimulation should be used as supporting measure like a biofeedback mechanism because of its low effective intensity. Despite of the good therapeutic success (51.5%) with lasting effects no objective criteria to the use of physical therapy in female stress incontinence were found

Hosker G., Norton C., and Brazzelli M. (2000) Electrical stimulation for faecal incontinence in adults. *Cochrane. Database. Syst. Rev.* CD001310.
Abstract: BACKGROUND: Faecal incontinence is a particularly embarrassing and distressing condition with significant medical, social and economic implications. Electrical stimulation has been used with apparent success in the treatment of faecal incontinence. However, standards of treatment are still lacking and the magnitude of alleged benefits has yet to be established. OBJECTIVES: To determine the effects of electrical stimulation for the treatment of faecal incontinence in adults. SEARCH STRATEGY: We searched the Cochrane Incontinence Group trials register, the Cochrane Controlled Trials Register, Medline, Embase and reference lists of potentially eligible articles up to November 1999. Date of the most recent searches: November 1999. SELECTION CRITERIA: All randomised or quasi-randomised trials evaluating electrical stimulation in adults with faecal incontinence. DATA COLLECTION AND ANALYSIS: Three reviewers assessed the methodological quality of potentially eligible trials and two reviewers independently extracted data from the included trial. A wide range of outcome measures were considered. MAIN RESULTS: Only one eligible trial with 40 participants was identified. It was a randomised trial, but it suffered from methodological drawbacks and did not follow up patients beyond the end of the trial period. Findings from this trial suggest that electrical stimulation with anal biofeedback and exercises provides more short-term benefits than vaginal biofeedback and exercises for women with obstetric-related faecal incontinence. No further conclusions could be drawn from the data available. REVIEWER'S CONCLUSIONS: At present, there are insufficient data to allow reliable conclusions to be drawn on the effects of electrical stimulation in the management of faecal incontinence. There is a suggestion that electrical stimulation may have a therapeutic effect, but this is not certain. Larger, more generalisable trials are needed

Hughes S.F., Scott S.M., Pilot M.A., and Williams N.S. (1995) Electrically stimulated colonic reservoir for total anorectal reconstruction. *Br. J. Surg.* 82, 1321-1326.
Abstract: Total anorectal reconstruction after abdominoperineal excision of the rectum has failed to achieve perfect continence. Electrically stimulated reservoir evacuation in combination with an electrically stimulated gracilis neoanal sphincter might improve results. A J pouch was constructed in an isolated colonic loop of seven dogs. Bipolar square wave pulses were delivered via two intramural stainless steel electrode pairs at 10 Hz. Stimulation parameters were varied to achieve adequate contraction. Serosal strain gauges recorded spontaneous and stimulated pouch motility. Evacuation was quantified by a volume displacement technique and observed fluoroscopically. Recordings were performed for a median of 3 (range 1-11) months. At 10 Hz and 0.5 ms pulse width, stimulation was required for 2 min and at voltages of 15 V (n = 4), 18 V (n = 1) and 20 V (n = 2) to obtain a contraction of amplitude comparable to that of a spontaneous contraction. Suprathreshold stimulation invariably resulted in colonic pouch contraction. The mean(95 per cent confidence interval (c.i.)) stimulus- response latency was 25.5(1.9) s. The mean(95 per cent c.i.) intraluminal pressure generated during stimulation was 114.1(17.0) cmH₂O and 64.6(12.0) cmH₂O during spontaneous activity (P < 0.001). In conclusion, electrical stimulation via intramural electrodes produced contraction generating sufficient intraluminal pressure to effect evacuation of a canine colonic pouch. This has potential for incorporation with an electrically stimulated neoanal sphincter in total anorectal reconstruction to improve evacuation and continence

Hugonnet C.L., Danuser H., Springer J.P., and Studer U.E. (2001) Urethral sensitivity and the impact on urinary continence in patients with an ileal bladder substitute after cystectomy. *J. Urol.* 165, 1502-1505.
Abstract: **PURPOSE:** After cystectomy and ileal bladder substitution, sensitivity in the membranous urethra correlates with postoperative urinary continence. We determine whether sensitivity is decreased only in the most proximal part of the urethra or also more distally in the bulbar urethra, which would give some indication as to which nerves may be injured during radical cystoprostatectomy. **MATERIALS AND METHODS:** The sensory threshold for electrical stimulation was measured with double ring electrodes in the membranous urethra, and 2.5 cm. distally to it in 41 men after cystectomy and ileal bladder substitution, and in a control group of 29 men. **RESULTS:** The mean sensory threshold plus or minus standard deviation of the membranous urethra was 9 +/- 2 mA. in the control group compared to 26 +/- 11 mA. in the postoperative group (p <0.001). Mean sensory threshold 2.5 cm. distal to the membranous urethra was 8 +/- 3 versus 9 +/- 3 mA. in the control and postoperative groups, respectively (not significant). Patients with daytime continence had a mean threshold of 22 +/- 8 mA. in the membranous urethra compared to 38 +/- 11 mA. in those who were incontinent (p <0.004) and a threshold of 8 +/- 3 mA. 2.5 cm. distal to the membranous urethra compared to 8 +/- 2 mA. in those who were incontinent (not significant). **CONCLUSIONS:** After cystectomy and ileal bladder substitution, urethral sensitivity 2.5 cm. distal to the membranous urethra is unaffected by surgery and does not correlate with postoperative continence. In contrast, a decreased sensitivity in the membranous urethra correlates with an increased risk of postoperative incontinence. Preservation of sensitivity in the membranous urethra seems to be an important factor for achieving continence after cystectomy and ileal bladder substitution, and does not seem to be dependent on the extrapelvic portion of the pudendal nerve

Ince L.P., Brucker B.S., and Alba A. (1978) Conditioned responding of the neurogenic bladder. *Psychosom. Med.* 40, 14-24.

Abstract: Classical conditioning techniques were employed to condition responding of the spastic neurogenic bladder in a man with quadriplegia and urinary incontinence secondary to spinal cord injury at the cervical level. A neutral stimulus of mild electrical stimulation to the thigh was paired temporally with an unconditioned stimulus (UCS) of stronger electrical stimulation of the lower abdomen, and then was presented alone as a conditioned stimulus (CS) to elicit the conditioned response (CR) of voiding. The previously neutral CS reliably elicited large amounts of urine and left little residual urine in the subject's bladder. Following the experimental sessions, the subject self-applied the CS on a predetermined schedule during his daily routine outside of the laboratory. The CS initially was successful, but after several days the CR exhibited extinction. Additional CS-UCS pairing sessions did not reinstate the responses satisfactorily. Aspects of the experimental procedure and the results are discussed as well as the feasibility of conditioning the human spinal cord in the absence of an intact central nervous system

Indrekvam S., Fosse O.A., and Hunnskaar S. (2001) A Norwegian national cohort of 3198 women treated with home-managed electrical stimulation for urinary incontinence--demography and medical history. *Scand. J. Urol. Nephrol.* 35, 26-31.

Abstract: OBJECTIVE: The aim of this study was to describe the demography, medical history and clinical characteristics of women treated with home-managed electrical stimulation in Norway. MATERIAL AND METHODS: This prospective cohort study investigated all 3198 women treated with home-managed electrical stimulation in Norway from 1992 to 1994. Data were collected from both patients and physicians by questionnaires before and after treatment. RESULTS: Mean age was 53 years. According to the physicians, 43, 15, 37 and 5% of the patients had stress, urge, mixed incontinence and other diagnoses, respectively. Fifty-five per cent of the women had had symptoms for 5 years or more, 62% had urinary loss every day/night, and 59% of the patients were classified as having severe or very severe incontinence according to a validated severity index. Fifty-two per cent of the women used a long-term stimulator and 48% a maximal stimulator. Of 645 physicians who requested stimulators, 65% worked in general practice; 70% of the stimulators were requested by physicians working in hospital or specialists in private practice. Gynaecologists requested 53% of the stimulators. CONCLUSIONS: The Norwegian reimbursement system can be said to be a numeric success. Electrical stimulation is a treatment option for everyday use in Norway. This complete national cohort of 3198 women treated with home-managed electrical stimulation for urinary incontinence was biased towards younger patients and more severe incontinence

Indrekvam S., Sandvik H., and Hunnskaar S. (2001) A Norwegian national cohort of 3198 women treated with home-managed electrical stimulation for urinary incontinence--effectiveness and treatment results. *Scand. J. Urol. Nephrol.* 35, 32-39.

Abstract: OBJECTIVE: The aim of this study was to analyse the effectiveness of home-managed electrical stimulation. MATERIAL AND METHODS: A prospective cohort study was conducted on all 3198 women treated with home-managed electrical stimulation in Norway during 1992-1994. Data were collected from both patients and physicians by questionnaires before and after treatment. RESULTS: 29% of the women were cured or much improved according to their own assessment; altogether 61% were improved. According to the physicians' assessment, 33% were cured or much improved; a total of 55% was improved.

Thirty-seven per cent of compliers and 12% of non-compliers regarded themselves as cured or much improved. The number of incontinence episodes, amount of leakage and use of pads decreased significantly; and 44% had less severe incontinence than before treatment according to a validated severity index.

CONCLUSIONS: Women treated with electrical stimulation for urinary incontinence experienced a significant reduction in incontinence problems, both subjectively and semi-objectively. The treatment results seem to be strongly dependent on good acceptance of the treatment

Ishigooka M., Ishii N., Hashimoto T., Suzuki Y., Adachi M., Nakada T., Saito C., Ichie M., and Handa Y. (1992) Electrical stimulation of pelvic floor musculature by percutaneous implantable electrodes: a case report. *Int. Urol. Nephrol.* 24, 277-282. Abstract: A forty-year-old man with reflex urinary incontinence due to spinal cord injury was treated with electrical stimulation of the pelvic floor musculature. In this case we employed percutaneous implantable electrodes and an external pulse regulator. After 4 weeks of stimulation incontinence was improved and urodynamically maximum cystometric capacity increased from 220 ml to 350 ml. Our method is easy and not invasive. This technique can be an alternative for the electrical stimulation for urinary incontinence

Ishigooka M., Hashimoto T., Izumiya K., Katoh T., Yaguchi H., Nakada T., Handa Y., and Hoshimiya N. (1993) Electrical pelvic floor stimulation in the management of urinary incontinence due to neuropathic overactive bladder. *Front Med. Biol. Eng* 5, 1-10. Abstract: Electrical pelvic floor stimulation employing a portable functional electrical stimulation system with percutaneously indwelling electrodes was carried out to improve detrusor urinary incontinence. Cyclic stimulation using negative going pulse trains of 20 Hz was applied 3 to 6 times daily to the bilateral pudendal nerves distributing to the pelvic floor muscles for the purpose of strengthening these muscles, including the urethral sphincter, and simultaneously, suppressing detrusor overactivity and increasing cystometric capacity. Electrical training for 4-8 weeks resulted in an improvement of urinary incontinence in five of six patients. In two of six cases incontinence had subjectively disappeared. Urodynamic investigations demonstrated an increase in detrusor reflex threshold and less tendency for abortive detrusor contraction. No apparent complications were encountered during these periods. This procedure appears to be efficient for the management of patients with detrusor incontinence who respond poorly to conservative therapies

Ishigooka M., Hashimoto T., Sasagawa I., Nakada T., and Handa Y. (1993) Technique of percutaneous electrode implantation for electrical pelvic floor stimulation. *Eur. Urol.* 23, 413-416. Abstract: A modified technique of electrical pelvic floor stimulation is described in detail. Six patients suffering from detrusor urinary incontinence underwent percutaneous electrode implantation for electrical pelvic floor stimulation. By this procedure adequate muscle contraction was obtained with a significant rise in urethral closure pressure. Detrusor reflex thresholds were increased in 5 of 6 patients at the initial stimulation. Percutaneous implantation appears to be an easy and noninvasive technique. This method provides stable and adequate effects on the pelvic floor structure and may be used in chronic electrical stimulation

Ishigooka M., Hashimoto T., Sasagawa I., Nakada T., and Handa Y. (1994) Electrical pelvic floor stimulation by percutaneous implantable electrode. *Br. J. Urol.* 74, 191-194.

Abstract: OBJECTIVE: To describe a clinical experience of chronic pelvic floor stimulation using a percutaneous implantable electrode for the treatment of urinary incontinence. PATIENTS AND METHODS: Pelvic floor stimulation using a percutaneous procedure was performed in 10 patients who were suffering from urinary incontinence due to overactive detrusor function. After implantation of the electrode chronic stimulation was instituted with a portable external electrical stimulator. RESULTS: Four to 16 weeks of maximal electrical stimulation improved urinary incontinence in eight of 10 patients. In two of these eight patients incontinence disappeared as measured subjectively. Urodynamic investigations demonstrated a significantly increased volume at the first unstable contraction ($P < 0.01$) in all patients. One of 30 electrodes migrated during the follow-up period. CONCLUSION: Inhibition of detrusor overactivity was obtained using this procedure. Response appeared to be constant during chronic stimulation. This procedure appears to provide stable and reliable stimulation for chronic treatment of urinary incontinence and may be an alternative to electrical pelvic floor stimulation

Ishigooka M., Hashimoto T., Hayami S., Suzuki Y., Nakada T., and Handa Y. (1996) Electrical pelvic floor stimulation: a possible alternative treatment for reflex urinary incontinence in patients with spinal cord injury. *Spinal Cord.* 34, 411-415.

Abstract: The present study demonstrates the clinical experience of pelvic floor stimulation using percutaneous implantable electrodes and implantable electrical stimulator for the treatment of reflex urinary incontinence in patients with spinal cord injury. Pelvic floor stimulation was carried out on six paraplegic patients who had urinary incontinence from an overactive bladder. After the percutaneous implantation of a pair of electrodes, chronic stimulation was carried out by employing an implanted receiver or an external pulse regulator. Within 4 to 16 weeks of electrical stimulation urinary incontinence was improved in four of the six patients. In two of these six patients, incontinence was completely abolished subjectively. Urodynamic investigations demonstrated an increased volume at the first unstable contraction ($P < 0.01$) in all of the patients. Inhibition of detrusor overactivity was obtained from this procedure. The stimulation effect appeared to be constant during chronic stimulation. This new procedure probably provides a stable and reliable stimulation effect for long term treatment, and may be an alternative treatment for previous external electrical pelvic floor stimulation

Ishii T., Takamura C., Esa A., Park Y.C., Mitsubayashi S., Kaneko S., and Kurita T. (1989) [A study of urinary incontinence after prostatectomy]. *Nippon Hinyokika Gakkai Zasshi* 80, 1474-1480.

Abstract: With respect to prostatectomies carried out in clinic since the opening of the Kinki University Hospital in 1975, incontinence after prostatectomy was investigated with 470 patients as subjects for whom a follow-up study after the operation was possible. Also, the usefulness of the urodynamic tests for diagnosing underlying diseases was investigated. 1) Overall incidence of incontinence after transurethral resection of the prostate (TUR-P), retropubic prostatectomy (RPP) and cryoprostatectomy was 5.7 percent. 2) The incidence of incontinence was 7.1 percent of the patients with TUR-P and 3.5 percent of patients with RPP. The incidence of incontinence after cryoprostatectomy was none. 3) There was no clear differences among the incidence of incontinence after prostatectomy and the weight

of resected tissues. 4) There was no clear differences among various types of incontinence after each procedures of prostatectomies. 5) The incontinence was satisfactorily treated and disappeared in 18 patients within one year after the operation. In patients who failed to get continence within a year, the incontinence was likely to persist furthermore. 6) The cure rate was low in patients with abnormal findings in a cystometrogram performed prior to the operation. Associated diseases which could cause disorders in nervous system were frequently encountered in such patients. 7) Drugs and functional electrical stimulation (FES) were introduced for the treatment of incontinence after prostatectomy. FES was effective in 36.4 percent in which drug therapy was not effective. Since multiple drug regimen was administered in most of the patients, it was difficult to make a precise evaluation of judgement for effect of each of drugs

Jabs C.F. and Stanton S.L. (2001) Urge incontinence and detrusor instability. *Int. Urogynecol. J. Pelvic. Floor. Dysfunct.* 12, 58-68.

Abstract: Detrusor instability is a syndrome of urinary frequency, urgency and urge incontinence which can be demonstrated using urodynamic studies to document uninhibited bladder contractions. Idiopathic cases account for 90% and 10% are related to neurologic disorders. Several different treatment modalities are available, including bladder training/drill, electrical stimulation, medical and surgical therapies

James E.D. (1968) Equipment and methods involved in the treatment of urinary incontinence by electrical stimulation. *Med. Biol. Eng* 6, 595-602.

Janez J., Plevnik S., and Suhel P. (1979) Urethral and bladder responses to anal electrical stimulation. *J. Urol.* 122, 192-194.

Abstract: Urethral and bladder responses to anal electrical stimulation were evaluated by cystometry and urethral pressure profile measurements in 55 patients with different urethral-bladder dysfunctions. In 50 per cent of the patients examined the electrical stimulation caused normal reciprocal response, that is bladder inhibition with urethral contraction. In other patients the electrical stimulation caused almost all other possible bladder and urethral responses

Janez J., Plevnik S., and Vrtacnik P. (1981) Maximal electrical stimulation for female urinary incontinence. *Prog. Clin. Biol. Res.* 78, 369-372.

Janknegt R.A., Baeten C.G., Weil E.H., and Spaans F. (1992) Electrically stimulated gracilis sphincter for treatment of bladder sphincter incontinence. *Lancet* 340, 1129-1130.

Abstract: Correction of total urinary incontinence due to sphincter damage is done with an artificial sphincter prosthesis or urinary diversion. In this pilot study we used graciloplasty around the bladder neck followed by electrical stimulation of this muscle with an implanted stimulator, which could be switched off and on by a magnet. Stimulus variables could be changed externally. With the stimulator on, urethral pressures of about 50 cm H₂O were obtained. Of three patients who underwent the procedure, two became continent and one improved but remained incontinent. Dynamic graciloplasty can restore urinary incontinence

Janknegt R.A., Weil E.H., and Eerdmans P.H. (1997) Improving neuromodulation technique for refractory voiding dysfunctions: two-stage implant. *Urology* 49, 358-362.

Abstract: OBJECTIVES: Neuromodulation is a new technique that uses electrical stimulation of the sacral nerves for patients with refractory urinary urge/frequency or urge-incontinence, and some forms of urinary retention. The limiting factor for receiving an implant is often a failure of the percutaneous nerve evaluation (PNE) test. Present publications mention only about a 50% success score for PNE of all patients, although the micturition diaries and urodynamic parameters are similar. We wanted to investigate whether PNE results improved by using a permanent electrode as a PNE test. This would show that improvement of the PNE technique is feasible. METHODS: In 10 patients where the original PNE had failed to improve the micturition diary parameters more than 50%, a permanent electrode was implanted by operation. It was connected to an external stimulator. In those cases where the patients improved according to their micturition diary by more than 50% during a period of 4 days, the external stimulator was replaced by a permanent subcutaneous neurostimulator. RESULTS: Eight of the 10 patients had a good to very good result (60% to 90% improvement) during the testing period and received their implant 5 to 14 days after the first stage. CONCLUSIONS: The good results of the two-stage implant technique we used indicate that the development of better PNE electrodes may lead to an improvement of the testing technique and better selection between nonresponders and technical failures

Jeyaseelan S.M., Haslam E.J., Winstanley J., Roe B.H., and Oldham J.A. (2000) An evaluation of a new pattern of electrical stimulation as a treatment for urinary stress incontinence: a randomized, double-blind, controlled trial. Clin. Rehabil. 14, 631-640. Abstract: OBJECTIVE: To evaluate a new pattern of electrical of electrical stimulation as a treatment for stress incontinence. DESIGN: A randomized, double-blind, controlled trial. SETTING: The study took place on three clinical sites. SUBJECTS: Patients (n = 27) with urodynamically proven stress incontinence recruited via consultant referral. INTERVENTIONS: Patients were randomly allocated to one of two groups: the new pattern of stimulation or sham stimulation. MAIN OUTCOME MEASURES: Patients were assessed pre, mid and post treatment using: perineometry, digital assessment and pad testing. The following were only used pre and post treatment: seven-day frequency/volume chart, SF-36, the Incontinence Impact Questionnaire and the Urogenital Distress Inventory. RESULTS: No significant between-group differences were highlighted except when quality of life was assessed with the Urogenital Distress Inventory ($p = 0.01$). A significant reduction in scores was observed in the stimulation group ($p = 0.03$) However, improvements were seen in both the strength and endurance characteristics of the pelvic floor musculature, although these changes were not translated into a reduction in symptoms. CONCLUSION: Although promising, the improvement in pelvic floor function did not result in a reduction in symptoms in all patients. Further research is required to investigate the effects of the new stimulation in combination with pelvic floor exercises and to compare the new stimulation pattern with existing forms of electrical stimulation

Jeyaseelan S.M. and Oldham J.A. (2000) Electrical stimulation as a treatment for stress incontinence. Br. J. Nurs. 9, 1001-1007.

Abstract: Much research has been conducted into the use of electrical stimulation to restore function in weak/atrophied muscle and it is used widely in the field of muscle rehabilitation. As stress incontinence is a condition which is the result of pelvic floor muscle weakness, it is thought that the symptoms of this condition may be alleviated once the strength and endurance characteristics of this muscle group have been

improved. Many studies have been conducted to evaluate the efficacy of various types of electrical stimulation, although definitive conclusions have yet to be drawn. Current forms of electrical stimulation for stress incontinence involve the use of uniform frequencies. In animal studies this type of stimulation has been shown to have drawbacks that are unacceptable when trying to rehabilitate muscle. Consequently, there is a need to develop more physiological patterns of stimulation that will enhance both strength and endurance characteristics without causing premature fatigue

Jiang C.H. and Lindstrom S. (1998) Prolonged increase in micturition threshold volume by anogenital afferent stimulation in the rat. *Br. J. Urol.* 82, 398-403.
Abstract: OBJECTIVE: To investigate whether anogenital afferent stimulation induces a prolonged increase in the micturition threshold volume of anaesthetized rats. MATERIALS AND METHODS: Thirteen female rats, anaesthetized by alpha-chloralose and paralysed by pancuronium bromide were used for the experiments. The micturition threshold volume was determined by repeated cystometry. In two experiments, afferent activity was recorded from the exposed pudendal nerve; vaginal and anal afferents were stimulated electrically by ring electrodes. In one experiment, the dorsal clitoris nerves were exposed bilaterally and mounted for electrical stimulation. The afferents were stimulated continuously for 5 min at 10 Hz, using unipolar cathodic pulses of 0.5 ms duration with an amplitude of 10 mA (or 0.8 mA for the dorsal clitoral nerves). RESULTS: Anogenital stimulation for 5 min induced a significant and prolonged increase in the micturition threshold volume (from a median value of 0.35 mL before to 0.45 mL after stimulation; $P < 0.01$). The increase in threshold volume was maintained for about 40 min after the end of stimulation. There was no obvious difference in effect between the stimulation sites nor with direct dorsal clitoral nerve stimulation. Neither the micturition threshold pressure nor the maximal contraction pressure were altered by stimulation. No tonic afferent after-discharge could be detected in the pudendal nerve recordings. CONCLUSIONS: Artificial electrical stimulation of anogenital afferents induced a prolonged increase in the micturition threshold volume of anaesthetized rats. The change presumably involved the modulation of the synaptic transmission in the central micturition reflex pathway. It is proposed that the observed change represents the first step in the curative 're-education' process induced in patients with urge incontinence by electrical stimulation of anovaginal afferents

Jonasson A., Larsson B., Pschera H., and Nylund L. (1990) Short-term maximal electrical stimulation--a conservative treatment of urinary incontinence. *Gynecol. Obstet. Invest* 30, 120-123.
Abstract: Seventeen women with stress and 20 with motor-urge urinary incontinence were treated ambulatorily with short-term maximal electrical stimulation. The duration of the treatment was 20 min daily for 12 weeks. According to the patients' subjective evaluation, two thirds were improved. A markedly diminished leakage of urine (greater than 50% by use of pad test) was found in 6 out of 17 women with stress, and in 13 out of 20 women with motor-urge urinary incontinence. There were no significant differences observed in urodynamic parameters between the registrations performed before and after the present electrical stimulation therapy

Kaiho Y., Namima T., Uchi K., Nakagawa H., Aizawa M., and Orikasa S. (1999)
[Electromyographic study of the striated urethral sphincter by using the bulbocavernosus reflex: study of the normal voluntary voiding and the involuntary

sphincter relaxation]. *Nippon Hinyokika Gakkai Zasshi* 90, 893-900.

Abstract: **PURPOSE:** The aim of this study was to investigate the sacral reflex activity at the striated urethral sphincter relaxation by evoking the potential of the bulbocavernosus reflex (BCR). **METHODS:** 17 normal male subjects were investigated. BCR was elicited by electrical stimulation of dorsal nerve of the penis, and the evoked potential of the BCR (BCR-EP) was recorded by a concentric needle electrode at the periurethral striated muscle. In normal subjects BCR was performed at rest and during voluntary voiding. In 8 of the normal subjects electrical stimulation was increased gradually during voluntary voiding, and changes of BCR-EP were studied. 3 male patients with neurogenic bladder suffering from urinary incontinence caused by involuntary sphincter relaxation (IVSR) were also investigated. In these patients with neurogenic bladder, BCR was performed at rest and during voluntary voiding as well as during involuntary voiding. **RESULTS:** In the normal subjects stable BCR-EP was elicited at rest and disappeared during voluntary voiding. But a gradually increased larger stimulation clearly demonstrated BCR-EP during voluntary voiding. In 3 patients with neurogenic bladder, stable ECR-EP was elicited at rest. During involuntary voiding caused by IVSR obvious BCR-EP was also elicited, but its amplitude was slightly less than the amplitude of BCR-EP at rest. During voluntary voiding in 2 of the 3 patients BCR-EP was recognized but the amplitude was much less, and in the third patient BCR-EP could not be recognized. **CONCLUSION:** BCR-EP was suppressed during voluntary voiding in normal subjects, but insufficiently suppressed in the patients with neurogenic bladder. In these patients BCR-EP during voluntary voiding was suppressed more distinctly than BCR-EP during involuntary voiding due to IVSR. In urodynamic study, the detrusor contraction and the sphincter relaxation were common phenomenon in both voluntary voiding and involuntary voiding, but the difference in the degree of the BCR suppression depended on whether micturition was voluntary or involuntary. It was suggested that the measurement of BCR-EP could distinguish involuntary voiding caused by pathological urethral sphincter relaxation from voluntary voiding

Kamm M.A. (1998) Diagnostic, pharmacological, surgical and behavioural developments in benign anorectal disease. *Eur. J. Surg. Suppl* 119-123.

Abstract: The investigation of benign anorectal disease has been transformed by new techniques of imaging such as anal endosonography and magnetic resonance imaging. This has led to more specific surgical treatments when structural damage is identified. It has also led to the identification of newly recognised pathologies, such as primary internal sphincter degeneration which causes passive faecal incontinence. A variety of new treatment modalities is also emerging. Pharmacological therapies are assuming great importance in relation to anal disease, with topical glyceryl trinitrate now the first treatment of choice for chronic anal fissure. For patients with intractable constipation behavioural techniques to modify pelvic floor and intestinal function are now the mainstay of therapy. New approaches to the surgical therapy of incontinence include the use of an artificial bowel sphincter, and the electrical stimulation of sacral nerves to modify pelvic floor function

Keating J.C., Jr., Schulte E.A., and Miller E. (1988) Conservative care of urinary incontinence in the elderly. *J. Manipulative Physiol Ther.* 11, 300-308.

Abstract: Urinary incontinence is a common, costly and demoralizing problem among the elderly. Remedial efforts are often not attempted owing to the misconception that incontinence is an inevitable and irreversible characteristic of aging. In fact, a variety

of relatively conservative methods of reducing geriatric incontinence are available. This paper reviews the categories of incontinence, outlines assessment strategies and critiques the literature on biofeedback, exercise, behavior therapy and electrical stimulation as treatments for geriatric incontinence, and briefly considers a role for the chiropractic physician

Kennedy M.L., Nguyen H., Lubowski D.Z., and King D.W. (1996) Stimulated gracilis neosphincter: a new procedure for anal incontinence. *Aust. N. Z. J. Surg.* 66, 353-357.

Abstract: BACKGROUND: The gracilis muscle has been used previously to construct an anal neosphincter, but this was not successful since a short-lived muscle contraction was insufficient to restore continence. Recently, a procedure was described in which conversion to a fatigue-resistant muscle was achieved by chronic low frequency electrical stimulation, and the resultant ability to sustain a constant contraction was associated with improved continence. Our initial results with this procedure, using a standardized operation and treatment protocol in 12 consecutive patients, is reported. METHODS: Seven women (mean age 50 years, range 22-71 years) had faecal incontinence, and five patients (F:M, 3:2; aged 53-72 years) underwent reconstruction after abdominoperineal excision of the rectum for cancer. A detailed questionnaire including continence score was completed pre-operatively. Eight patients have been assessed after ileostomy closure at a mean time of 10 months. RESULTS: Slow-twitch muscle conversion was achieved in each case and all patients have a functional neosphincter. Mean continence score was 6.8 (range 4-12), and seven patients were continent. There was significant improvement in continence in the non- cancer group ($p = 0.03$). Mean pre-operative resting anal pressure, functional neosphincter pressure (NPfunc), and maximal neosphincter pressure (NP(max)) were 36, 102 and 207 cmH₂O, respectively. There was a significant improvement in pressure comparing NPfunc ($P = 0.03$) and NP(max) ($P = 0.03$) with pre-operative pressure. Complications included deep vein thrombosis, pulmonary embolism, saphenous nerve injury, leg wound haematoma, and late pacemaker infection. CONCLUSION: The stimulated gracilis neosphincter achieves satisfactory continence in a majority of patients

Kerrigan D.D., Lucas M.G., Sun W.M., Donnelly T.C., and Read N.W. (1989) Idiopathic constipation associated with impaired urethrovesical and sacral reflex function. *Br. J. Surg.* 76, 748-751.

Abstract: Sixteen chronically constipated women (age range 20-66 years) and 29 healthy control subjects (age range 22-53 years) underwent neurophysiological assessment of the integrity of pelvic spinal reflexes. The results were compared with videourodynamic studies and multiport anorectal manometry combined with external anal sphincter electromyography. The neurophysiological assessment consisted of electrical stimulation of the dorsogenital nerve, while recording any evoked reflex activity in the external anal and urethral sphincters with concentric needle and surface electrodes. Of these constipated women, 75 per cent had absence of one or more evoked sacral reflexes (compared with 20 per cent of healthy controls, P less than 0.05). Sensory thresholds and motor unit potentials in the external anal sphincter were similar in healthy and constipated women. Nine (56 per cent) constipated women displayed urodynamic abnormalities (increased bladder capacity, acontractile bladder and genuine stress incontinence). Only 38 per cent of constipated women perceived a desire to defaecate during rectal distension with up to 100 ml, compared with 95 per cent of normal subjects (P less than 0.0005).

Moreover, 73 per cent of constipated women did not relax the external anal sphincter during defaecation, compared with 12 per cent of controls ($P = 0.001$). Taking into account the possible significance of our data in relation to previous findings it is suggested that the integration of sensory information within the sacral cord may be impaired in chronic idiopathic constipation

Kirsch S.E., Shandling B., Watson S.L., Gilmour R.F., and Pape K.E. (1993) Continence following electrical stimulation and EMG biofeedback in a teenager with imperforate anus. *J. Pediatr. Surg.* 28, 1408-1409.

Abstract: A teenage boy with repaired high imperforate anus relied on daily enemas for social continence. After treatment with low intensity transcutaneous electrical stimulation and electromyographic biofeedback home programs, he achieved improved fecal continence requiring only one enema per month

Konsten J., Baeten C.G., Havenith M.G., and Soeters P.B. (1993) Morphology of dynamic graciloplasty compared with the anal sphincter. *Dis. Colon Rectum* 36, 559-563.

Abstract: Dynamic graciloplasty for fecal incontinence includes gracilis muscle transposition around the anal canal as a new sphincter and subsequent electrical stimulation. The aim of electrical stimulation is to transform the gracilis fast-twitch, "fatigue-prone" fibers into slow-twitch, "fatigue-resistant" fibers to achieve a sustained tonic contraction. The latter is considered essential for sphincter function. Therefore, the following features of transposed gracilis muscle morphology were studied in nine patients before and after electrical stimulation: 1) the percentage of Type I fibers, 2) the lesser diameter of these fibers, and 3) the positive collagen staining area. Furthermore, the external and sphincter and gracilis muscle histology was investigated in six autopsy cases. The mean percentage of Type I, slow-twitch, fatigue-resistant fibers in transposed gracilis muscle increased from 46 percent before electrical stimulation to 64 percent ($P < 0.01$, paired Student's t-test) after electrical stimulation. The mean lesser diameter of these fibers did not change significantly (from 32 to 29 microns), and the mean percentage of collagen increased from 4 percent before electrical stimulation to 7 percent ($P < 0.01$) afterward. The external sphincter in cadavers demonstrated a predominance of Type I fibers (80 percent) with a lesser diameter of 23 microns and a high percentage (12 percent) of collagen. Gracilis muscle histology was uniform at six different sample sites in these cadaver dissections. We conclude that electrical stimulation induces histologic changes in transposed gracilis muscle, allowing this muscle to function as an external anal sphincter

Konsten J., Baeten C.G., Havenith M.G., and Oei T.K. (1993) Evaluation of gracilis muscle transposition for fecal incontinence with magnetic resonance imaging. *Eur. J. Radiol.* 16, 190-194.

Abstract: Ten consecutive patients with incapacitating fecal incontinence were treated with 'anal dynamic graciloplasty' (transposition of the gracilis muscle around the anal canal and implantation of intramuscular electrodes connected with an implanted pulse generator, 6 weeks later) to achieve continence. We measured the gracilis muscle diameter immediately after transposition and before implantation of the stimulation device. It was found that gracilis diameter decreased from 12 (5 days after transposition) to 8 mm, 6 weeks later (mean decrease: 4 mm (95% confidence interval 3.6), $n = 10$, $P < 0.05$). In addition, morphology demonstrated a decrease of both Type I and Type II muscle fiber diameter and an increase in endomyosial

collagen. Despite this decrease in muscle (and muscle fiber) diameter, electrical stimulation of the transposed gracilis muscle increased the pressure into the anal canal from 37 to 55 mmHg (mean increase: 17 mmHg (95% confidence interval 6.29), $P < 0.05$). Fecal continence was achieved in seven (70%) of these patients. Further analysis revealed no correlations between reduction of the gracilis muscle diameter before implantation of the stimulation device and clinical outcome in terms of achieved continence and/or anal canal pressures. MRI is an excellent method to demonstrate the shape of gracilis muscle after transposition. However, the size of transposed gracilis muscle is not associated with the functional outcome

Konsten J., Baeten C.G., Spaans F., Havenith M.G., and Soeters P.B. (1993) Follow-up of anal dynamic graciloplasty for fecal continence. *World J. Surg.* 17, 404-408.
Abstract: The feasibility of anal dynamic graciloplasty (transposition of the gracilis muscle and subsequent implantation of a stimulation device) to restore continence, was assessed in a case-control study of 26 patients with severe fecal incontinence. It was shown that anal dynamic graciloplasty is capable of achieving the sphincter tone of healthy persons, as stimulated graciloplasty increased anal pressure from 46 mmHg without stimulation to 65 mmHg with stimulation (mean increase 19 mmHg; 95% confidence interval 13, 25; $n = 25$; $p < 0.01$). Time to retain a 250-ml phosphate enema increased from 52 seconds before to 204 seconds after 8 weeks of electrical stimulation (mean increase 151 seconds; 95% confidence interval 61, 241; $n = 25$; $p < 0.01$). Complete fecal continence was achieved in 17 patients (65%); two of these patients developed a wound infection, but one of the two realized continence without stimulation and the other patient became continent after reimplantation. Three other patients improved after anal dynamic graciloplasty, but infection necessitated removal of the stimulation device. One patient developed a fistula. Failures were encountered in five patients. Although our long-term follow-up results suggest a learning curve, it is concluded that electrical stimulation improves the results of conventional graciloplasty and avoids construction of a colostomy

Konsten J., Baeten C.G., Havenith M.G., and Soeters P.B. (1994) Canine model for treatment of faecal incontinence using transposed and electrically stimulated sartorius muscle. *Br. J. Surg.* 81, 466-469.
Abstract: A neosphincter was successfully created around each end of a Thiry-Vella loop in five dogs using transposed sartorius muscle to study new treatments for faecal incontinence. One of these dynamic neosphincters in each dog was electrically trained for 8 weeks while the other served as a control. Muscle biopsies demonstrated an increase in type 1 fatigue-resistant fibres from a median of 49 (range 37-54) per cent before electrical stimulation to 78 (range 53-99) per cent 8 weeks later in the stimulated sartorius neosphincters ($P < 0.05$), whereas the percentage of type 1 fibres in control neosphincters increased only slightly. Retention times of saline increased from a median of 10 (range 5-50)s before to 340 (range 100-470)s after electrical stimulation ($P < 0.05$) but also increased in control neosphincters (to 370 (range 330-1200)s); this may indicate that electrical stimulation immediately increases acute retention times. It is concluded that construction of a neosphincter is technically feasible with preservation of muscle morphology and that stimulation induces morphological and functional changes towards the characteristics of the external anal sphincter

Konsten J., Geerdes B., Baeten C.G., Heineman E., Arends J.W., Pette D., and Soeters P.B. (1995) Dynamic myoplasty in growing dogs as a feasibility study for treatment of

fecal incontinence. *J. Pediatr. Surg.* 30, 580-584.

Abstract: The feasibility of skeletal muscle transposition and electrical stimulation (dynamic myoplasty) for treatment of fecal incontinence has been shown in adults. It might be attractive to use such a technique in pediatric patients. Therefore, the influence of growth on skeletal muscle transposition and stimulation was studied in five puppies. In each dog, two neosphincters were constructed around a Thiry-Vella loop by using a dissected sartorius muscle with the neurovascular supply intact. In each of these five puppies, one of these muscles was electrically stimulated during a mean of 19 weeks (one puppy died during the first postoperative week). Muscle biopsies showed an increase in the percentage type I, fatigue-resistant muscle fibers from 61 to 94 in electrically stimulated sartorius neosphincters, but also an increase from 57 to 67 percent in transposed nonstimulated sartorius muscles. The diameter of these type I fibers during growth increased 36% in electrically stimulated sartorius neosphincters and 55% in nonstimulated sphincters. Function of the neosphincters was tested with the inflow of saline in the Thiry-Vella loop. It was shown that the stimulated neosphincters were capable of inhibiting flow (which corresponded to manometric pressure registrations), but the nonstimulated sphincters were unable to inhibit flow. The experiments were complicated by infection and necrosis around the implanted stimulators in four puppies (which required reimplantation). We conclude that a dynamic myoplasty for fecal incontinence is feasible in growing puppies but that the technique is unacceptable during rapid growth because of the risks of infection and dislocation of the implanted device

Kontani H., Nakagawa M., and Sakai T. (1992) Effects of adrenergic agonists on an experimental urinary incontinence model in anesthetized rabbits. *Jpn. J. Pharmacol.* 58, 339-346.

Abstract: We have developed an experimental urinary incontinence model in anesthetized female rabbits, in order to study the effects of alpha- adrenergic receptor agonists on it in vivo. Micturition was induced artificially by electrical stimulation of the abdomen of rabbits receiving a continuous infusion of glucose-free Tyrode's solution into the urinary bladder. Alpha-1 adrenergic agonists, phenylephrine (1 mg/kg, i.v.) and the newly synthesized agent ST-1059 (1 mg/kg, i.v.) and its prodrug midodrine (10 mg/kg), which was intraduodenally administered, elevated the bladder pressure and arrested micturition induced by electrical stimulation. Prazosin (0.1 mg/kg, i.v.) inhibited these effects of phenylephrine. The effect of an alpha-2 agonist, clonidine (1 mg/kg, i.v.), on micturition induced by electrical stimulation was not clearly defined. This study demonstrates that alpha- 1 adrenergic agonists can arrest artificially-induced micturition via urethral contraction. This method may be useful for evaluating the effect of a drug on urethral leakage in vivo

Kontani H. and Hayashi K. (1997) Urinary bladder response to hypogastric nerve stimulation after bilateral resection of the pelvic nerve or spinal cord injury in rats. *Int. J. Urol.* 4, 394-400.

Abstract: BACKGROUND: We examined the mechanism of urinary bladder motility return after bladder areflexia induced by interruption of the sacral parasympathetic outflow to the urinary bladder following damage to the sacral cord or pelvic nerves in the rat. METHODS: The L6 and S1 nerve bundles were resected near the vertebrae, and bilateral pelvic nerve resections (PNR) performed. Spinal cord injury (SCI) was performed by means of a legion generator at the T12 vertebra. Thirty days after PNR and SCI, cystometrograms were recorded under anesthesia. RESULTS: In all rats

subjected to PNR or SCI, overflow incontinence continued, yet some rats subjected to SCI recovered within 2 weeks after the operation. Cystometrograms showed that repetitive bladder contractions appeared in rats subjected to SCI irrespective of hypogastric nerve (HGN) innervation, while bladder contractions did not appear in rats subjected to PNR. Electrical stimulation of the HGN induced higher bladder pressure elevation in rats who underwent PNR than in rats subjected to SCI. CONCLUSIONS: These results suggest that the generation of repetitive bladder contractions induced by bladder distention after bladder areflexia requires the presence of intact pelvic nerves that transmit sacral cord-originating excitatory information to the bladder. However, the HGN system and functioning pelvic nerve ganglia are not involved in this process. Also, the connection from the preganglionic HGN to the postganglionic parasympathetic nerves in the pelvic plexus did not form after PNR

Kralj B. (1982) [Selection of patients in the treatment of urinary incontinence]. *Jugosl. Ginekol. Opstet.* 22, 1-3.

Abstract: Criteria for the selection of female patients with urinary incontinence for treatment are described. The following procedures are suggested: the patient's history, gynecological examination, urological examination, urodynamic examinations (urethral pressure profile and cystometry), and neurophysiological examinations (especially the electromyography of pelvic floor muscles). For the treatment with functional electrical stimulation the role of the trial application of stimulators is emphasized. The importance of an accurate classification of incontinence is stressed. The results of treatment depend mainly on the appropriate selection of patients

Kralj B. (1999) Conservative treatment of female stress urinary incontinence with functional electrical stimulation. *Eur. J. Obstet. Gynecol. Reprod. Biol.* 85, 53-56.

Abstract: BACKGROUND: Treatment of stress urinary incontinence with functional electrical stimulation (FES) is a recent and efficient method of conservative treatment. STUDY DESIGN: Before treatment, examinations determining the type of urinary incontinence should be made: patient history, pelvic and urologic examination, laboratory tests of urine, multi-channel urodynamic tests. The degree of urinary incontinence is assessed by pad tests. Only the patients with moderate stress urinary incontinence without or with a mild utero-vaginal prolapse, are treated by FES. The parameters of stimulation: the impulse is rectangular and biphasic, duration of impulse is 1 ms, frequency of impulse is 20 Hz, and intensity of current 35 mA. The chronic treatment with FES should be applied 1.5-2 h daily for 3 months. This long-term treatment requires appropriate motivation of the patient. RESULTS: Three months after terminated treatment 56 of the total 111 patients (50.5%) were cured, in 26 (23.4%) the condition improved, whereas in 29 patients (26.1%) the treatment failed. CONCLUSIONS: The efficiency of treatment depends on the patient selection, parameters of electrical stimulation, stimulator of the pelvic floor muscles, mode of stimulation--chronic stimulation, and on motivation of the patient

Kulseng-Hanssen S., Kristoffersen M., and Larsen E. (1998) Evaluation of the subjective and objective effect of maximal electrical stimulation in patients complaining of urge incontinence. *Acta Obstet. Gynecol. Scand. Suppl* 168, 12-15.

Abstract: BACKGROUND: Favorable results have been reported following Maximal Electrical Stimulation (MES) of patients with urgency and urge incontinence. However, patient groups have often been mixed and outcome measures poorly

defined. We therefore wanted to treat a homogeneous patient population with MES and evaluate the effect by defined subjective and objective outcome measures. METHODS: Eighteen female patients complaining of urge incontinence had MES performed. Before and 3 months after MES, the patients performed a 24 hour micturition chart and pad test. They indicated on a visual analogue scale their subjective degree of urgency and leakage and had an ambulatory urodynamic monitoring performed. Nine months after MES the patients were asked whether their urge incontinence was less, equal or more troublesome than before MES. RESULTS: After MES the patients indicated significantly less urgency and leakage. A significant difference was not found in any of the objective outcome measures after MES. Six out of 18 patients (33%) found their urge incontinence less troublesome 9 months after MES, while 12 (66%) found it unchanged or more troublesome than before. CONCLUSIONS: Significantly subjective effect was found following MES. However, none of the objective outcome measures were significantly improved. We were disappointed by the results and have stopped using the method

Lamhut P., Jackson T.W., and Wall L.L. (1992) The treatment of urinary incontinence with electrical stimulation in nursing home patients: a pilot study. *J. Am. Geriatr. Soc.* 40, 48-52.

Abstract: OBJECTIVES: To test the effectiveness of electrical stimulation in the treatment of urinary incontinence in female nursing home patients. SETTING: A community long term care facility. PARTICIPANTS: Nine unselected female nursing home patients with urinary incontinence. All patients were moderately to severely cognitively impaired. By bedside cystometry, six patients had involuntary detrusor contractions while two had inconclusive results. INTERVENTION: Participants were treated with electrical stimulation for 8 weeks using the Microgyn II device. A current with a frequency of 20 hertz and a pulse width of 1 millisecond was delivered repeatedly for 2 seconds on, 4 seconds off for 15 seconds twice a week. MEASUREMENTS: The number of every-2-hour wet episodes during a 48-hour period (Wet) was recorded by a blinded observer at baseline and after 4 and 8 weeks of treatment. We evaluated the overall effect of electrical stimulation by averaging the Wet at 4 and 8 weeks for each patient and comparing it to Wet at baseline. MAIN RESULTS: The mean +/- standard deviation of intensity of electrical stimulation was 12 +/- 5 milliamps. Mean Wet at baseline was 11.8 +/- 4.2. For all patients mean Wet increased by 2.3 +/- 3.2, $P = 0.07$. Analysis of patients with documented involuntary detrusor contractions showed a mean increase in Wet of 2.6 +/- 3.6, $P = 0.16$. The volume of fluid at which an involuntary contraction occurred during cystometry showed a mean increase of 48.3 +/- 52.6 mL, $P = 0.07$ after 8 weeks of treatment. CONCLUSIONS: Electrical stimulation is well tolerated in elderly nursing home patients. However, it was ineffective in improving urinary incontinence. In fact, there was a tendency for the treatment to worsen the incontinence

Lanmuller H., Bijak M., Mayr W., Rafolt D., Sauermann S., and Thoma H. (1997) Useful applications and limits of battery powered implants in functional electrical stimulations. *Artif. Organs* 21, 210-212.

Abstract: Battery powered stimulation implants have been well-known for a long time as heart pacemakers. In the last few years, fully implantable stimulators have been used in the field of functional electrical stimulation (FES) for applications like dynamic cardiomyoplasty and electro-stimulated graciloplasty for fecal incontinence. The error rate of battery powered implants is significantly smaller than that for conventional stimulator systems, and the quality of life for the patients is increased because the

need for an external power and control unit is eliminated. The use of battery powered implants is limited by the complexity of the stimulation control strategies and the battery capacity. Therefore, applications like the stimulation of lower extremities for walking, cochlea stimulation, or direct muscle stimulation cannot be supported. The improvement of implantable batteries, microcontrollers, and ultralow power products is ongoing. In the future, battery powered implants will also meet the requirements of complex applications. Systems for restoration of hand and breathing functions after spinal cord injury can be the next field of use for battery powered implants. For these purposes, we developed a battery powered multichannel implant with a sufficient life span for phrenic pacing. The problems during development and the limits of this system are described in this paper

Lazareff J.A., Mata-Acosta A.M., Garcia-Mendez M.A., and Escanero-Salazar A. (1990) [Selective limited posterior rhizotomy at 3 dorsal levels. A variant for the neurosurgical treatment of spasticity]. *Bol. Med. Hosp. Infant Mex.* 47, 72-77.
Abstract: INTRODUCTION. Selective posterior rhizotomy (SPR) is effective for reducing spasticity associated to infantile cerebral palsy (ICP). To avoid excessive muscular hypotone a different surgical technique is proposed. PATIENTS AND METHODS. Sixteen children with spasticity secondary to ICP were evaluated before and after rhizotomy. The degree of spasticity was compared in the lower an in the upper limbs. Dorsal roots of levels L4, L5, and S1 were analyzed and sectioned according to the results yielded by intraoperative electrical stimulation. RESULTS. Spasticity was reduced in all the muscular groups analyzed. One of the patients had bladder incontinence. CONCLUSIONS. The limited surgical procedure is sufficient for reducing spasticity

Leroi A.M., Ducrotte P., Bouaniche M., Touchais J.Y., Weber J., and Denis P. (1997) Assessment of the reliability of cerebral potentials evoked by electrical stimulation of the anal canal. *Int. J. Colorectal Dis.* 12, 335-339.
Abstract: The aim of this study was to assess the reliability of cortical evoked potentials after electrical stimulation of the anal canal. Cortical evoked potentials were recorded on 243 patients presenting with perineal pain (28 patients), impotence (55 patients), anal incontinence (52 patients), urinary continence (30 patients), constipation (49 patients), and on 29 neurological patients, by stimulating the external anal sphincter and penis (or clitoris). The i

Lewey J. and Lilas L. (1999) Electrical stimulation of the overactive bladder. *Prof. Nurse* 15, 211-214.
Abstract: Bladder overactivity is a significant health-care problem. Electrical stimulation has been shown to be a safe and effective treatment option. Careful patient selection may improve results obtained with this technique. Further studies are required to determine optimal treatment parameters

Lightner D.J. and Itano N.M. (1999) Treatment options for women with stress urinary incontinence. *Mayo Clin. Proc.* 74, 1149-1156.
Abstract: About one-quarter million surgical procedures are performed each year in the United States for stress urinary incontinence. After outlining the presentation and diagnostic evaluation of stress urinary incontinence, this review concentrates specifically on the numerous conservative management strategies and minimally invasive surgical options for women with this common complaint. In the evaluation of nursing home residents with incontinence, the Minimum Data Set and Resident

Assessment Protocol facilitate nonspecialist evaluation and management. In healthy adults, the therapeutic implications of the physical examination of the pelvic floor, assessing for the presence and strength of the voluntary contraction of the pelvic floor muscles, are detailed as the basis for all conservative management strategies. Reports on the effectiveness of pelvic floor muscle reeducation and pelvic floor electrical stimulation vary substantially, as do long-term results of surgical interventions. Surgical management is highly effective in the appropriate candidate. The current theory and practice of surgical treatment of stress urinary incontinence are outlined, with certain caveats regarding the lack of long-term follow-up for newer less invasive techniques

Lindstrom S., Fall M., Carlsson C.A., and Erlandson B.E. (1983) The neurophysiological basis of bladder inhibition in response to intravaginal electrical stimulation. *J. Urol.* 129, 405-410.

Abstract: Intravaginal electrical stimulation (IVS) induces a profound bladder inhibition and is successful in the treatment of incontinence due to detrusor instability. In this experimental study in cats, direct recordings of the efferent activity in thin hypogastric and pelvic nerve filaments to the bladder were used to analyze the neuronal mechanisms underlying this bladder inhibition. A longlasting reflex discharge, with a latency of 35 to 50 msec., was evoked in the hypogastric nerve by IVS. The reflex discharge was unaffected by imposed changes in intravesical pressure or by micturition contractions, but the response was very frequency-sensitive with an optimal transmission at about 5 Hz of stimulation. A "spontaneous" efferent activity could be recorded in the pelvic nerve filaments when the bladder pressure was elevated above 5 to 7 cm. H₂O. The pelvic activity occurred in 10 to 20-second bursts, each followed by an abortive detrusor contraction. IVS of 5 to 10 Hz completely abolished this efferent pelvic activity by central inhibition. The findings are discussed in relation to the normal neuronal control of the bladder and to the clinical application of IVS

Lobe T.E. (1984) Fecal continence following an anterior-sagittal ano-enteroplasty in a patient with cloacal exstrophy. *J. Pediatr. Surg.* 19, 843-845.

Abstract: A two-year-old Latin American female was referred for treatment of what appeared to be a straightforward case of cloacal exstrophy. At operation, incision along the superior margin of the exstrophic bladder allowed identification of an unusual variant of exstrophy which consisted of bladder exstrophy; terminal colon duplication, the common medial wall of which protruded 8 cm beyond the end of the bowel lumen, and which exited ventrally and immediately caudad to the exstrophic bladder; an enteric diverticulum at the superior rim of the bladder; and two small vaginae, existing laterally on either side, at the junction between the bladder and the terminal bowel. The terminal bowel was mobilized, the duplications were excised, and a tapering enteroplasty was performed. Despite a flat-appearing bottom, a posterior muscle complex was identified which extended anterolaterally and attached to the pubis on either side. Following observation of an appropriate response to electrical stimulation, the muscle complex was partially divided in the midline, from anterior to posterior, just enough to make room for the tapered bowel. The muscle was then reapproximated in the midline anteriorly, surrounding the bowel, and an anoplasty was constructed. The bladder was closed, and the pubic rami were wired together (bilateral posterior iliac osteotomies were performed at the beginning of the operation). One and 1/2 years following this procedure, the child has a normal

"rectal" exam with a palpable sphincter. She has 3 to 4 solid bowel movements daily without soiling, and she awaits genitourinary reconstruction

Luber K.M. and Wolde-Tsadik G. (1997) Efficacy of functional electrical stimulation in treating genuine stress incontinence: a randomized clinical trial. *Neurourol. Urodyn.* 16, 543-551.

Abstract: Our objective was to determine the efficacy of functional electrical stimulation as a stand-alone therapy for female stress incontinence. The study was conducted as a prospective, double-blind, randomized controlled trial using subjective and objective outcome criteria. Patients enrolled in this study had stress incontinence consistent with International Continence Society criteria. Patients with significant pelvic prolapse or detrusor instability were excluded. Patients underwent twice-daily treatment sessions for a total of 3 months. Results were analyzed for confounding variables between the treatment and control groups. Statistical analysis was performed utilizing Fisher's exact test and the paired t-test. Of the 54 patients enrolled in this study, 44 completed the program. The dropout rate was similar for both the treatment and control groups. There was no statistically significant difference between the treatment and control groups with regard to age, gravity, parity, previous antiincontinence surgery, menopausal status, or previous hysterectomy. Objective success for the treatment group was 15% and for the control group, 12.5% (NS). The subjective success for the treatment group was 25% and for the control group, 29% (NS). There was no relationship demonstrated between age, parity, previous surgery, hysterectomy, or menopausal status and the successful treatment of genuine stress incontinence with functional electrical stimulation. In this patient population, functional electrical stimulation was no more effective at improving or eliminating the symptoms of genuine stress incontinence than was the daily retention of the control probe

Lundeberg T. (1996) Electrical stimulation techniques. *Lancet* 348, 1672-1673.

Madersbacher H. (1978) [The effect of transurethral electrical stimulation on the paralyzed and incontinent bladder: objective results (author's transl)]. *Urologe A* 17, 355-357.

Abstract: Using objective parameters, improvement of the detrusor function and bladder sensitivity can be obtained in most children. A significant improvement in incontinence appears possible in 30--40% of the patients. The method according to Katona is the only one which creates bladder sensitivity. This method is not a cure all but has improved our therapeutic possibilities, especially when it is combined with pharmacotherapy, long term low dose antibiotic therapy and sphincterotomy

Malissard M., Souquet J., and Jullien D. (1994) Optimisation of pulse duration for intravaginal electrical stimulation: effect of tissue excitability. *Med. Biol. Eng Comput.* 32, 327-330.

Mander B.J., Abercrombie J.F., George B.D., and Williams N.S. (1996) The electrically stimulated gracilis neosphincter incorporated as part of total anorectal reconstruction after abdominoperineal excision of the rectum. *Ann. Surg.* 224, 702-709.

Abstract: OBJECTIVE: The authors investigated the feasibility and effectiveness of combining electrically stimulated gracilis neoanal (ESGN) sphincter and a coloperineal anastomosis in selected patients after abdominoperineal excision of the rectum (APER). SUMMARY BACKGROUND DATA: The ESGN is effective in the

treatment of idiopathic fecal incontinence. **METHODS:** Between March 1989 and September 1993, 12 patients (9 men, 3 women) with a median age of 59.25 years (range, 45- 70) underwent the procedure. The underlying disease was adenocarcinoma in 10, anal malignant melanoma in 1, and a sweat gland tumor in the other. In all patients, a sphincter saving resection was contraindicated. The procedure was performed in stages. Stage 1 involved a conventional APER with the formation of a perineal stoma. Eleven patients underwent a vascular delay procedure. All patients were defunctioned. In stage 2, the gracilis was mobilized, transposed around the anal canal, and the electrodes and hardware needed for electrical stimulation were implanted. Once muscle conversion was complete, the defunctioning stoma was closed. **RESULTS:** Eight patients were closed successfully. In seven of the eight patients, complete physiologic measurements were taken. Median basal and maximum neosphincter pressures were 30 and 122 cm H₂O, respectively, at the start of electrical stimulation and 22.5 and 76.2 cm H₂O, respectively, after 1 year. Median functioning neosphincter pressure was 36 cm H₂O at 1 year. All of the patients whose stomas were closed experienced episodes of incontinence to solid stool and wore pads for persistent fecal soiling. They all reported difficulty in evacuation. Despite imperfect continence, no patient wished to go back to life with a stoma. **CONCLUSIONS:** The incorporation of ESGN as part of total anorectal reconstruction is technically feasible. The majority of patients are satisfied with their function and pleased to avoid a permanent stoma

Mander B.J. and Williams N.S. (1996) Electrical stimulation of sacral nerves for treatment of incontinence. *Lancet* 347, 63-64.

Marshall D.F. and Boston V.E. (1997) Altered bladder and bowel function following cutaneous electrical field stimulation in children with spina bifida--interim results of a randomized double-blind placebo-controlled trial. *Eur. J. Pediatr. Surg.* 7 Suppl 1, 41-43.

Abstract: Bladder and bowel dysfunction in spina bifida are the result of abnormal electrical input, secondary to the neurological lesion of the spinal cord. Experimental attempts to correct this deficit with invasive electrical stimulation have demonstrated promising effects, as has a recent preliminary study of transcutaneous electro-stimulation in children with myelomeningocele. A randomized controlled trial of non-invasive electrical stimulation in children with neuropathic bladder and bowel has been established. Interim results of 50 patients are presented. Treatment was performed at home for one hour daily for a mean period of 45 days. The only statistically significant difference between the active and placebo-groups was a 32% relative decrease in night-time urinary incontinence, favoring the placebo group. However there were non-significant trends of preferential improvement in the active group for the relative increases in maximum and average bladder content and episodes of spontaneous normal defecation. It is anticipated that a continued increase in patient numbers will overcome the large placebo effect observed and yield more significant results

Mathers S.E., Ingram D.A., and Swash M. (1990) Electrophysiology of motor pathways for sphincter control in multiple sclerosis. *J. Neurol. Neurosurg. Psychiatry* 53, 955-960.

Abstract: The central and peripheral motor pathways serving striated sphincter muscle function were studied using cortical and lumbar transcutaneous electrical stimulation, pudendal nerve stimulation and sphincter electromyography in 23

patients with multiple sclerosis (MS), and sphincter disturbance, including incontinence of urine or faeces, urinary voiding dysfunction, or constipation. The central motor conduction time was significantly increased in the MS group compared to controls (p less than 0.05). Damage to both the upper and lower motor neuron pathways can contribute to sphincter disturbance in MS. The latter may be due to coexisting pathology or to involvement of the conus medullaris by MS

Matzel K.E., Stadelmaier U., and Gall F.P. (1995) [Direct electrostimulation of sacral spinal nerves within the scope of the diagnosis of anorectal function]. *Langenbecks Arch. Chir* 380, 184-188.

Abstract: A technique is demonstrated to evaluate the functional relevance of the sacral spinal nerves regarding anal sphincter function. Sacral spinal nerves S2, S3, S4 can be reached selectively for electrical stimulation by a dorsal approach through the sacral foramina. Electrical stimulation of S3 and S4 results in visible contraction of the different striated muscular anal sphincter components and in an increase of anal canal closure pressure. These effects differ among individuals. Thus, the functional relevance of each single sacral spinal nerve on the striated muscular anal sphincter can be tested specifically

Matzel K.E., Stadelmaier U., Hohenfellner M., and Gall F.P. (1995) Electrical stimulation of sacral spinal nerves for treatment of faecal incontinence. *Lancet* 346, 1124-1127.

Abstract: Functional deficits of the striated anal sphincteric muscles without any apparent gross defect often result in a lack of ability to postpone defaecation by intention or in faecal incontinence in response to increased intra-abdominal or intra-rectal pressure. We applied electrostimulation to the sacral spinal nerves to increase function of the striated muscles of the anal sphincter. Of three patients followed for 6 months, two gained full continence and one improved from gross incontinence to minor soiling. Closure pressure of the anal canal increased in all. Preliminary data indicate that anal closure pressure increases with the duration of stimulation. Continuous stimulation of sacral spinal nerves can help some patients with faecal incontinence. It may be possible to promote continence with intermittent stimulation

McGuire E.J., Zhang S.C., Horwinski E.R., and Lytton B. (1983) Treatment of motor and sensory detrusor instability by electrical stimulation. *J. Urol.* 129, 78-79.

Abstract: A new application of electrical stimulation to inhibit detrusor activity has been used in 15 patients with a variety of neural lesions. The results were astonishingly good and the device was well tolerated. In patients treated successfully for detrusor instability an absence of urgency occurred as a by-product of electrical stimulation. Therefore, stimulation was used to treat uncomfortable bladder urgency without detrusor instability and was successful in the majority of patients

McIntosh L.J., Frahm J.D., Mallett V.T., and Richardson D.A. (1993) Pelvic floor rehabilitation in the treatment of incontinence. *J. Reprod. Med.* 38, 662-666.

Abstract: This study assessed the effectiveness of a pelvic floor rehabilitation program in a clinical practice. A retrospective convenience sample of 48 women was evaluated pretreatment and posttreatment with follow-up interviews from six months to three years. This group consisted of 81% with stress urinary incontinence, 6% with unstable bladder and 10% with mixed incontinence. Fecal incontinence was present as well in 35% of the subjects. The patients were taught pelvic floor muscle exercises and instruction reinforced with electromyographic biofeedback. Neuromuscular electrical stimulation was used when clinically indicated. Two women

did not continue the program beyond the first visit and were excluded. Sixty-two percent of patients with two or more visits demonstrated an improvement. Thirteen percent were completely dry, and 49% demonstrated a significant improvement. Patients with genuine stress urinary incontinence, unstable bladder and mixed incontinence showed a 66%, 33% and 50% improvement rate, respectively. Fecal incontinence was improved in 63% of women trained in pelvic floor muscle exercises. A significant decrease ($P < .001$) was found in the frequency of self-reported leakage at the six-month to three-year follow-up. The strength and duration of a pelvic muscle contraction was significantly greater between the first and last visit in all patients, regardless of the subjective improvement. A pelvic floor rehabilitation program was an effective alternative to surgical intervention in reducing the frequency of urinary leakage. Further studies are needed to identify factors predicting success and to determine the most cost-effective method of achieving pelvic floor rehabilitation

Melick W.F. (1970) Electrical stimulation in urology. *J. Urol.* 103, 815-821.

Merrill D.C., Conway C., and DeWolf W. (1975) Urinary incontinence. Treatment with electrical stimulation of the pelvic floor. *Urology* 5, 67-72.

Abstract: Electrical pelvic floor stimulation may be administered either externally by the transrectal tampon or internally with the implantable pelvic floor stimulator. This treatment modality requires intact pelvic floor innervation and therefore is unsuccessful in patients with pelvic floor denervation. Pelvic floor stimulation has been successful in patients with stress and with congenital, iatrogenic, and postoperative urinary incontinence

Merrill D.C. (1979) The treatment of detrusor incontinence by electrical stimulation. *J. Urol.* 122, 515-517.

Abstract: Cystometrograms were done on 20 patients before and during transrectal stimulation to determine if electrical stimulation increased the detrusor reflex threshold. In 4 patients the detrusor reflex threshold was increased during stimulation and urinary continence was restored. However, each patient became incontinent when transrectal stimulation was discontinued for 1 to 5 days. Thus, cyclic periods of stimulation were necessary to maintain the beneficial effects of electrical stimulation and a permanent pelvic floor stimulator was implanted since chronic transrectal stimulation was inconvenient

Merton P.A., Hill D.K., Morton H.B., and Marsden C.D. (1982) Scope of a technique for electrical stimulation of human brain, spinal cord, and muscle. *Lancet* 2, 597-600.

Abstract: Brief high-voltage electrical shocks from a special low-output-resistance stimulator, delivered through electrodes on the skin, can excite human muscle directly (not by way of the nerves) and can also excite the motor cortex, the visual cortex, and the spinal cord. Possible applications of the technique include measurement in muscle disorders of the latency relaxation and of the excitability and contractility of muscle without the interposition of nerve fibres or the neuromuscular junction; measurement of conduction velocity in the pyramidal tract; and the detection of neuropathy in the nerves to the external sphincter ani

Miller K., Richardson D.A., Siegel S.W., Karram M.M., Blackwood N.B., and Sand P.K. (1998) Pelvic floor electrical stimulation for genuine stress incontinence: who will benefit and when? *Int. Urogynecol. J. Pelvic. Floor. Dysfunct.* 9, 265-270.

Abstract: This study sought to determine the characteristics of women in whom pelvic floor electrical stimulation will reduce stress urinary incontinence. It also evaluates how long electrical stimulation should be used before significant improvements are seen in clinical outcomes. Subjects with genuine stress incontinence were enrolled into a multicenter non-randomized trial. They used electrical stimulation for 15 minutes twice daily or every other day for 20 weeks. At the end of 20 weeks, those with a 50% reduction in leakage episodes on voiding diary ('responders') were compared with those who did not show a 50% reduction ('non-responders'). Thirty-one subjects were enrolled and 28 completed the study. After the treatment period, 19 subjects were defined as responders and 9 as non-responders. There were no significant differences between the two groups in baseline demographics (e.g. age, parity, largest birth weight etc.) other than body mass index (greater in nonresponders). Significant subjective and objective improvements were noted among responders by 10 and 14 weeks, respectively. Compliance was higher in responders during weeks 12-15 of the study (P=0.05). It was concluded that a minimum of 14 weeks of pelvic floor stimulation was necessary before significant objective improvements were seen. Body mass index and patient compliance may affect success

Mizunaga M., Morikawa M., Miyata M., Kaneko S., and Yachiku S. (1995) [A case of psychological non-neuropathic bladder successfully diagnosed by continuous monitoring of detrusor pressure]. *Nippon Hinyokika Gakkai Zasshi* 86, 337-340.
Abstract: We report a case of psychological non-neuropathic bladder difficult to diagnose and treat. A 44-year-old woman was admitted to the Department of Urology of the Asahikawa Medical College Hospital with complaints of difficulty in micturition and urinary incontinence. Urodynamic studies revealed underactive function of the detrusor and incompetent urethra. She was instructed in self intermittent catheterization for difficulty in micturition. Drug therapy, electrical stimulation and vesicourethral suspension were not effective to control urinary incontinence. Since uninhibited detrusor contraction was elicited by psychogenic stress during continuous monitoring of the detrusor function, she was diagnosed as psychological non-neuropathic bladder closely related to psychogenic factor. She had a careful counselling and medical treatment designed by her psychiatrist, urinary incontinence was remitted in about one year and a half

Montgomery E. and Shepherd A.M. (1983) Electrical stimulation and graded pelvic exercises for genuine stress incontinence. *Physiotherapy*. 69, 112.

Moore K.N. (1994) Electrical stimulation for the treatment of urinary incontinence: do we know enough to accept it as part of our practice? *J. Adv. Nurs.* 20, 1018-1022.
Abstract: While many nurses are involved in the treatment of incontinent patients, few are well-informed on electrical stimulation. In this paper, patient-controlled stimulation is discussed and implications for current nursing practice considered. The paper includes a discussion of the weaknesses in current research with electrostimulation and concludes with recommendations for future research in the treatment of incontinence with this new modality

Moore K.N., Griffiths D., and Hughton A. (1999) Urinary incontinence after radical prostatectomy: a randomized controlled trial comparing pelvic muscle exercises with or without electrical stimulation. *BJU. Int.* 83, 57-65.

Abstract: OBJECTIVES: To assess the effectiveness of intensive conservative

treatment on and the impact of urinary incontinence after radical retropubic prostatectomy. **PATIENTS AND METHODS:** Sixty-three men with urinary incontinence ≥ 8 weeks after radical prostatectomy were randomized to one of three groups; group 1, standard treatment (control); group 2, intensive pelvic muscle exercises (PME); or group 3, PME plus electrical stimulation (PME+ES). Group 1 received verbal and written instructions about postoperative PME from their urologist and from the nurses at the pre-admission clinic. Groups 2 and 3 were treated by a physiotherapist for 30 min twice a week for 12 weeks and carried out home exercises three times a day on the days when they were not treated. Outcome was assessed using the 24-h pad test, two validated quality-of-life questionnaires and a urine symptom inventory, all obtained at baseline, 12, 16 and 24 weeks after enrolment. The final pad test was carried out approximately 8 months after surgery. **RESULTS:** Fifty-eight patients completed the study, 21 in group 1, 18 in group 2 and 19 in group 3; five discontinued, three with bladder neck contractures requiring dilatation, one with rectal pain when doing the exercises and one unable to complete therapy while on vacation. The mean (median) time elapsed from surgery to entry into the study was 19 (8) weeks. At 12 weeks from baseline, the mean overall urine loss had decreased from 463 g to 115 g but there were no differences among groups, nor were there significant differences in urine loss at 16 and 24 weeks ($F=0.16$, $P=0.69$). There was a significant impact on quality of life during the early recovery. Despite preoperative instructions, many patients revealed little or no knowledge about catheter care, bladder spasms, rectal pain, incontinence and erectile dysfunction. Little of the preoperative education was retained because of the overwhelming nature of the diagnosis. **CONCLUSIONS:** From the initial assessment to the final pad-test at approximately 8 months after surgery, incontinence improved greatly in all three groups. This rapid improvement may have masked any treatment benefit. Further research should address incontinence in men whose urine loss has stabilized and who underwent surgery >8 months previously. Moreover, a telephone-based follow-up soon after discharge may alleviate many of the concerns expressed

Moore K.N., Cody D.J., and Glazener C.M. (2000) Conservative management of post prostatectomy incontinence. *Cochrane Database Syst. Rev.* CD001843.
Abstract: **BACKGROUND:** Urinary incontinence after prostatectomy is a common problem. Conservative management of this condition includes pelvic floor muscle training, biofeedback, electrical stimulation using a rectal electrode, transcutaneous electrical nerve stimulation, or a combination of methods. **OBJECTIVES:** To assess the effects of conservative management for urinary incontinence after transurethral, suprapubic, radical retropubic or perineal prostatectomy. **SEARCH STRATEGY:** The Cochrane Incontinence Group's trials register, Medline, Cinahl, Embase, PsycLit and ERIC all up to January 1999, and reference lists of relevant articles. We contacted investigators to locate studies and we handsearched the following conference proceedings: American Urological Association (1989-1999); Society of Urologic Nurses and Associates (1991-1998); Wound Ostomy and Continence Nurses (1996-1999); and International Continence Society (1980-1998). Date of most recent searches: January 1999. **SELECTION CRITERIA:** Randomised or quasi-randomised trials which evaluated conservative management aimed at improving urinary continence after prostatectomy. **DATA COLLECTION AND ANALYSIS:** Two reviewers independently assessed the methodological quality of studies and abstracted data from included trials onto a standard form. **MAIN RESULTS:** Only five randomised trials were identified which included 365 men, each evaluating different treatments, and all studying men after radical prostatectomy. The trials were of

moderate quality and data were not available for many of the pre-stated outcomes. Confidence intervals for both dichotomous and continuous data were wide; it was not possible to reliably identify or rule out a useful effect. Men's symptoms tended to improve over time, irrespective of management. REVIEWER'S CONCLUSIONS: The value of the various approaches to conservative management of post prostatectomy incontinence remains uncertain. Further well designed trials are needed

Moore K.N. (2000) Treatment of urinary incontinence in men with electrical stimulation: is practice evidence-based? *J. Wound. Ostomy. Continence. Nurs.* 27, 20-31.
Abstract: Electrical stimulation is frequently recommended for the treatment of urinary incontinence in men. However, few randomized, controlled trials allow practitioners to evaluate the evidence base for this practice. The purpose of this article is to determine, based on a review of the literature, whether adequate evidence exists to support the use of electrical stimulation as a treatment of male urinary incontinence. Urge, stress, and overflow incontinence are evaluated separately. This review led to 3 conclusions: (1) theoretical and urodynamic evidence exists to support the use of electrical stimulation for urge incontinence, (2) conflicting evidence exists in the use of electrical stimulation for stress urinary incontinence, and (3) treatment of overflow incontinence in men has not been evaluated in a systematic way. For both stress urinary or overflow incontinence, practitioners should consider the existing research before recommending electrical stimulation as a first line of treatment. For urge incontinence, electrical stimulation may be an effective first-line treatment strategy

Moore K.N. and Jensen L. (2000) Testing of the Incontinence Impact Questionnaire (IIQ-7) with men after radical prostatectomy. *J. Wound. Ostomy. Continence. Nurs.* 27, 304-312.
Abstract: OBJECTIVE: The objective of this study was to test the validity and reliability of the Incontinence Impact Questionnaire (IIQ-7), a 7-item self-report instrument designed to assess the impact of urinary incontinence (UI), in men. SUBJECTS: Fifty-eight men with incontinence after radical prostatectomy were the subjects of the study. METHODS: Content validity was assessed by a panel of experts. Construct and criterion validity were examined with 3 groups of men who had UI in a randomized controlled trial comparing pelvic muscle exercises with pelvic muscle exercises plus electrical stimulation. Internal consistency and stability coefficients for the IIQ-7 were determined. RESULTS: The content validity index was 0.88. Four items were below the designated content validity index level. A 2-factor analysis solution (factor I-impact on daily activities; factor II-emotional impact) explained 84.94% of the variance. No significant group differences were recorded on impact of UI ($F = 0.37, P = .70$), nor were any differences among subjects found over time ($F = 0.90, P = .50$). A positive relationship was found between grams of urine loss on a 24-hour pad test and IIQ-7 scores ($r = 0.34, P = .003$ to $.51, P = .001$). When the IIQ-7 score decreased, self-reported quality of life improved as measured by the European Organization for the Research and Treatment of Cancer Quality of Life Questionnaire Version 2 ($r = -0.57, P = .0001$ to $-.49, P = .001$). A strong relationship was found between responses to the question "Does leakage affect your life?" and the IIQ-7 scores. Internal consistency ranged between 0.88 and 0.92. IIQ-7 scores were consistent when urine loss was stabilized between 16 and 24 weeks after entry into the study ($r = 0.89, P = .0001$). CONCLUSION: The IIQ-7 is a reliable measure of the impact of UI; however, the scale requires additional testing regarding construct validity in men

Moore T. and Schofield P.F. (1967) Treatment of stress incontinence by maximum perineal electrical stimulation. *Br. Med. J.* 3, 150-151.

Moul J.W. (1998) Pelvic muscle rehabilitation in males following prostatectomy. *Urol. Nurs.* 18, 296-301.

Abstract: Post-prostatectomy incontinence (PPI) is a common problem in the era of increased detection of prostate cancer and use of radical prostatectomy. Whether temporary or permanent, mild or more severe, PPI can be effectively treated and improved by pelvic muscle rehabilitation. It is important for urologic nurses to understand the various pelvic muscle rehabilitation methods--for example, Kegel exercises, biofeedback, and electrical stimulation--to better educate and care for PPI patients and their families

Nagasaki A. and Ikeda K. (1985) [Bowel control after surgery for Hirschsprung's disease]. *Nippon Geka Gakkai Zasshi* 86, 1287-1289.

Abstract: Bowel control was studied in 66 children operated by Ikeda's Z-shaped anastomosis for Hirschsprung's disease. At the age of 2 or 3 years, mild constipation was recognized in 16% of the children, incontinence in 12% and soiling in 28%. However, these disorders reduced as the patients grew up and finally over 7 years, constipation was seen in 8% of the patients, incontinence in 8% and soiling in 19%. According to barium enema, megarectum was seen in all constipated children but one, though slight megarectum was sometimes seen even in normal or incontinent children. Frequently, anal canal was wide and leakage of barium through the anus was seen in incontinent or soiling children. Anal canal pressure was high in constipated group, low in soiling group and the lowest in incontinent group. The appearance rate of rhythmical wave of anal canal and recto-anal reflex was the same among all groups. Our treatment of the constipation and incontinence is daily bowel movement using laxative, suppository or enema. For the incontinent patients without rectal sensation, biofeedback method or electrical stimulation is applied

Nakamura M., Sakurai T., Tsujimoto Y., and Tada Y. (1983) [Transcutaneous electrical stimulation for the control of frequency and urge incontinence]. *Hinyokika Kiyo* 29, 1053-1059.

Abstract: To control frequency, urgency and urge incontinence, transcutaneous electrical stimulation was applied to the tibial nerve, the pudendal nerve or the anal sphincter in 79 patients. All patients were refractory to any medications for the control of frequency, nocturia, urgency and urge incontinence from a variety of causes including disk protrusion, Parkinson's disease and idiopathic conditions. The parameters of stimulation were 0.1 to 0.5 msec. duration for each stimulus, frequency 10 to 40 Hz, amplitude 5 to 500 voltage. Cystometrography was repeated during and after electrical stimulation and showed increased bladder capacity, measured at first and/or at maximum desire to void, increased compliance, decreased bladder pressure and/or disappearance of uninhibited contractions in 79% of the patients examined. At least one of these changes was observed in 64, 72 and 85% of the patients who underwent stimulation of the tibial nerve, the pudendal nerve and the anal sphincter, respectively. In some patients inhibition of bladder contraction persisted for more than 2 or 3 days after stimulation. Electromyographic activity of the pelvic floor muscles increased in all of the patients during the stimulation of the pudendal nerve or the anal sphincter, but did not increase and rather decreased during stimulation of the tibial nerve. Urethral pressure measured during electrical stimulation, did not change in many cases. Clinical success was

also obtained in 19 of 22 patients who underwent two electrical stimulation program; one was continuous daily use of a portable stimulator, and the other was periodic anal stimulation once or twice a week.(ABSTRACT TRUNCATED AT 250 WORDS)

Nakamura M. and Sakurai T. (1984) Bladder inhibition by penile electrical stimulation. *Br. J. Urol.* 56, 413-415.

Abstract: Transcutaneous electrical stimulation was applied to the penis in 22 patients complaining of frequency, urgency and/or urge incontinence. Detrusor activity was suppressed with this stimulation, causing decreased bladder spasticity and/or increased cystometric capacity in 10 of 22 patients. Clinical success was noted in four patients with a portable stimulator

Nakamura M., Sakurai T., Tsujimoto Y., and Tada Y. (1986) Bladder inhibition by electrical stimulation of the perianal skin. *Urol. Int.* 41, 62-63.

Abstract: Transcutaneous electrical stimulation was applied to the perianal skin of 25 patients with frequency, urgency or incontinence. Repeated cystometrograms during this stimulation disclosed suppression of detrusor activity, inhibition of detrusor instability in 4 of 8 patients and increase of maximum cystometric capacity in 5 of 25 patients. Electromyographic activity of the anal sphincter muscle increased in all the 25 patients. Poststimulation improvement was observed clinically in 9 of 12 patients

Nakamura M., Sakurai T., Sugao H., and Sonoda T. (1987) Maximum electrical stimulation for urge incontinence. *Urol. Int.* 42, 285-287.

Abstract: Urge incontinence was controlled in 13 (62%) of 21 patients by maximum electrical stimulation which was applied to the anus or the perianal skin. The first session of maximum electrical stimulation was able to determine if this treatment would be successful. This method of patient selection for further stimulation was simple and reliable and achieved clinical success in all of 13 selected patients

Niriella D.A. and Deen K.I. (2000) Neosphincters in the management of faecal incontinence. *Br. J. Surg.* 87, 1617-1628.

Abstract: BACKGROUND: Surgical treatment of end-stage faecal incontinence has its origin in the early 1950s. Interest has been revived as a result of technical advances achieved in the recent past. The purpose of this article is to review the principles that underlie the use of skeletal muscle transposition around the anal canal and of electrical stimulation in the treatment of incontinence, and to explore new methods of treatment of this condition. METHODS: A literature search was performed using Pubmed and Medline, employing keywords related to treatment of faecal incontinence by neosphincter reconstruction. Basic science and clinical aspects of neosphincter reconstruction were gathered from relevant texts, original articles and recently published abstracts. RESULTS: The electrically stimulated gracilis neoanal sphincter seems to be the popular choice of biological neosphincter. It is more likely to produce higher resting anal canal pressures than the unstimulated neosphincter, and hence improved continence. However, electrostimulator failure may result in explantation in a proportion of patients. Impairment of evacuation is a functional setback in approximately one-third of patients with the gracilis neosphincter. Overall, improvement of continence may be expected in up to 90 per cent of patients according to some reports. By contrast, experience with the artificial neosphincter, which is less expensive, has been limited to a few tertiary centres across the world. Reported continence of stool is 100 per cent, and that of gas and stool 50 per cent, following implantation of the artificial sphincter. Both of the above

operations have been associated with implant-related infection and impaired evacuation. CONCLUSION: Neoanal sphincter operations are technically demanding, require a considerable learning experience and should be confined to specialist colorectal centres. Patients are likely to benefit from a plan that incorporates preoperative counselling and a selective approach

Norlen L. and Sundin T. (1982) Influence of the adrenergic nervous system on the lower urinary tract and its clinical implications. *Int. Rehabil. Med.* 4, 37-43.

Abstract: The morphology of the adrenergic nervous systems as well as adrenoceptor functions of the human lower urinary tract are outlined and compared to some animal studies. Special emphasis is given to the altered adrenergic innervation and adrenoceptor function after parasympathetic decentralization. Pharmacological treatment affecting adrenoceptors is described in different disturbances of lower urinary tract function and some evidence for adrenergic mechanisms working in intravaginal electrical stimulation is presented. The importance of the sympathetic nervous system for the normal function of the human lower urinary tract is still unclear. Nevertheless, clinical data obtained by treatment with agents influencing this system indicate that the contractory alpha-adrenoceptors of the human urethra can be stimulated or blocked pharmacologically producing significant changes in intraurethral pressure. On the other hand, the relaxatory effect on the human detrusor obtained by stimulation of the beta-adrenoceptors seems to be negligible

Norton C., Hosker G., and Brazzelli M. (2000) Biofeedback and/or sphincter exercises for the treatment of faecal incontinence in adults. *Cochrane. Database. Syst. Rev.* CD002111.

Abstract: BACKGROUND: Faecal incontinence is a particularly embarrassing and distressing condition with significant medical, social and economic implications. Sphincter exercises and biofeedback therapy have been used to treat the symptoms of people with faecal incontinence. However, standards of treatment are still lacking and the magnitude of alleged benefits has yet to be established. OBJECTIVES: To determine the effects of biofeedback and/or anal sphincter exercises/pelvic floor muscle training for the treatment of faecal incontinence in adults. SEARCH STRATEGY: We searched the Cochrane Incontinence Group trials register, the Cochrane Controlled Trials Register, Medline, Embase and all reference lists of relevant articles up to November 1999. Date of the most recent searches: November 1999. SELECTION CRITERIA: All randomised or quasi-randomised trials evaluating biofeedback and/or anal sphincter exercises in adults with faecal incontinence. DATA COLLECTION AND ANALYSIS: Three reviewers assessed the methodological quality of eligible trials and two reviewers independently extracted data from included trials. A wide range of outcome measures were considered. MAIN RESULTS: Only five eligible studies were identified with a total of 109 participants. In the majority of trials methodological quality was poor or uncertain. All trials were small and employed a limited range of outcome measures. Follow-up information was not consistently reported amongst trials. Only two trials provided data in a form suitable for statistical analyses. There are suggestions that rectal volume discrimination training improves continence more than sham training and that anal biofeedback combined with exercises and electrical stimulation provides more short-term benefits than vaginal biofeedback and exercises for women with obstetric-related faecal incontinence. Further conclusions are not warranted from the available data. REVIEWER'S CONCLUSIONS: The limited number of identified trials together with

their methodological weaknesses do not allow a reliable assessment of the possible role of sphincter exercises and biofeedback therapy in the management of people with faecal incontinence. There is a suggestions that some elements of biofeedback therapy and sphincter exercises may have a therapeutic effect, but this is not certain. Larger well-designed trials are needed to enable safe conclusions

Nygaard I.E. and Kreder K.J. (1996) Spine update. Urological management in patients with spinal cord injuries. *Spine* 21, 128-132.

Abstract: In the past, urologic complications contributed greatly to spinal cord injury mortality. With improved evaluation and treatment, this is no longer the case. Treatment should be guided by urodynamic data gathered after the resolution of spinal shock symptoms. Goals of treatment are to facilitate voiding, reduce incontinence, and prevent renal damage. Indwelling catheters are almost never indicated for long-term treatment of the neurogenic bladder. Commonly used treatments include intermittent catheterization, condom catheter drainage with sphincter ablation, and pharmaceutical manipulation. Electrical stimulation of sacral nerve roots shows promise for future therapy

Nygaard I.E. (1996) Nonoperative management of urinary incontinence. *Curr. Opin. Obstet. Gynecol.* 8, 347-350.

Abstract: Recent public health policies emphasize managing urinary incontinence nonoperatively, rather than proceeding directly to surgery. Advantages of this approach include decreased cost and risk. Additionally, incontinence treatment becomes accessible to many more women, by expanding care to nonspecialists. This article reviews data published in the past 18-24 months pertaining to conservative management of incontinence. Specific modalities reviewed include pelvic floor muscle exercises, electrical stimulation, medication, vaginal devices, and bladder training

O'Donnell P.D. (1998) Special considerations in elderly individuals with urinary incontinence. *Urology* 51, 20-23.

Abstract: OBJECTIVES: To describe special considerations related to the etiology, evaluation, and treatment of urinary incontinence (UI) in the elderly. METHODS: The characteristics of UI in older patients are contrasted with those in younger patients. Recommended evaluations for elderly individuals are reviewed, and treatment issues are addressed. RESULTS: The etiology of UI is more complex in older than in younger patients, and a different clinical approach is required. Bladder overactivity is a common underlying component of UI in the elderly patient regardless of the complexity of the etiology. The most common voiding symptom in elderly patients is urgency with urge UI. The evaluation of the older patient with UI should include a symptom assessment, physical examination, review of the medical history (particularly with regard to previous surgeries), and assessments of social environment and functional status (which can have an impact on the type of treatment selected and the success of therapy). Urodynamic evaluations are particularly important because of the complexity of UI in this population. Treatment options include pharmacologic therapies, behavioral interventions, electrical stimulation, and combination therapies. The combination of surgical and nonsurgical therapies may be particularly important in the future. CONCLUSIONS: Control of bladder overactivity is the most significant long-term challenge in the management of UI in the elderly. Successful treatment can produce a marked improvement in the quality of life for these individuals

- Ohlsson B., Lindstrom S., Erlandson B.E., and Fall M. (1986) Effects of some different pulse parameters on bladder inhibition and urethral closure during intravaginal electrical stimulation: an experimental study in the cat. *Med. Biol. Eng Comput.* 24, 27-33.
- Ohlsson B.L. and Erlandson B.E. (1988) Miniaturised device for long-term intravaginal electrical stimulation for the treatment of urinary incontinence. *Med. Biol. Eng Comput.* 26, 509-515.
- Ohlsson B.L. (1988) Effects of some different pulse parameters on the perception of intravaginal and intra-anal electrical stimulation. *Med. Biol. Eng Comput.* 26, 503-508.
- Ojemann J.G., Park T.S., Komanetsky R., Day R.A., and Kaufman B.A. (1997) Lack of specificity in electrophysiological identification of lower sacral roots during selective dorsal rhizotomy. *J. Neurosurg.* 86, 28-33.
Abstract: The authors investigated the efficacy of anal sphincter electromyography (EMG) in identifying the lower sacral roots during selective dorsal rhizotomy. In nine children undergoing selective dorsal rhizotomy for cerebral palsy (CP) spasticity, direct electrical stimulation of the L1-S5 dorsal and ventral roots was performed while monitoring EMG responses from the anal sphincter and lower-extremity muscles. Anal sphincter activation was seen with stimulation of lumbosacral roots at many levels. Stimulation of dorsal and ventral roots gave anal sphincter EMG responses in 100% of the dorsal and ventral roots from L-4 and caudally. Only at the L-1 level did a minority of nerve roots have anal sphincter response to stimulation. Patterns of extremity muscle and sphincter activation specific to the S3-5 roots, namely anal sphincter activation without activation of other muscle groups, were found in only five (22%) of 23 roots stimulated. The pattern of stimulation responses in the majority of S3- 5 roots indicated that the pathophysiology of lower-extremity spasticity in CP may involve the anal sphincter and does not spare the lower sacral roots. Thus, this study indicates that electrophysiological mapping alone, without anatomical identification, cannot be used to identify the lower sacral roots during selective dorsal rhizotomy for CP spasticity, and it proposes a model for investigation of associated bowel and bladder symptoms
- Okada N., Igawa Y., Ogawa A., and Nishizawa O. (1998) Transcutaneous electrical stimulation of thigh muscles in the treatment of detrusor overactivity. *Br. J. Urol.* 81, 560-564.
Abstract: OBJECTIVE: To investigate the clinical effects on detrusor overactivity of a new method of transcutaneous reciprocal electrical stimulation of the thigh muscles. PATIENTS AND METHODS: Nineteen patients with detrusor overactivity, comprising 14 with detrusor hyperreflexia (DH) and five with idiopathic detrusor instability (IDI), were studied. Electrical stimulation was applied alternately to the quadriceps and hamstring muscles of one or both legs through surface electrodes for 20 min. The treatment was given once a day for 14 days and then the patients were evaluated urodynamically. RESULTS: All 19 patients tolerated the therapy well and none reported any adverse effects. The mean maximum cystometric capacity increased significantly ($P < 0.05$) after treatment. In 11 of the 19 patients, the maximum cystometric capacity was increased by $> 50\%$ of the pretreatment value; this occurred in eight of 14 of those with DH and in three of five of those with IDI. In six of the 11 who responded in this way, there was a clinical improvement in their urinary

incontinence and frequency for several weeks to 3 months after the period of therapy. A second 14-day treatment was also effective in all four patients who underwent a repeat trial. CONCLUSION: This method of transcutaneous electrical stimulation can inhibit DH as well as IDI with no adverse effects. The suppressive effect on detrusor overactivity may persist for several months and repeat trials appear to be effective. Thus, we believe that this new stimulation technique should be tried as an alternative to other types of electrical stimulation and augmentation cystoplasty

Okada N., Igawa Y., and Nishizawa O. (1999) Functional electrical stimulation for detrusor instability. *Int. Urogynecol. J. Pelvic. Floor. Dysfunct.* 10, 329-335.
Abstract: The clinical efficacy of functional electrical stimulation (FES) for female detrusor instability (DI) is reviewed. Various types of FES methods (including anogenital long-term stimulation, short-term maximal stimulation, implantable stimulation and transcutaneous stimulation) have been reported. The therapeutic effects of these approaches were similar: the percentage of patients improved has been reported to be in the range 50%-90%. FES for female DI is a non-destructive procedure with a curative effect and very few side effects. This curative effect (re-education) is a major benefit of FES

Petersen T. (1987) Management of urinary incontinence in children with myelomeningocele. *Acta Neurol. Scand.* 75, 52-55.
Abstract: Several forms of treatment of lower urinary tract functional disorders have been attempted in children with myelomeningocele (MMC). Intravesical electrical stimulation was attempted in 10 patients. Urinary control was achieved in one and in the remaining 9 either the bladder was resistant to stimulation or the children discontinued the treatment due to loss of interest. A combined anticholinergic and calcium blocking agent, terodiline, was tested in 8: symptoms improved in 4, but bladder compliance was unchanged. Clean intermittent catheterization, either alone or in combination with medication, seems to be the most beneficial treatment

Plevnik S. (1976) Model of the proximal urethra: measurement of the urethral stress profile. *Urol. Int.* 31, 23-32.
Abstract: Research on the activity of the urinary tract has led to the creation of a theoretical mechanical model where elastic forces, affecting rigid segments represent the living tissue of the urethral walls whereby it is assumed that the tissue acts as an elastic material. Such a model provides a clearer picture of changes in the physical parameters of the elastic walls of the urethra and facilitates better analysis of measurement errors. Artefacts make it exceptionally difficult to accurately measure the urethral pressure profile. The known methods have a measurement error of at least 30%. We have been trying to eliminate the basic error caused by the size of the measuring sensor. The method involves measuring the urethral pressure profile in one patient using several sensors of varying diameters. The problem was defined mathematically. By extrapolation of measuring points, the value of elastic force under normal conditions can be obtained. Preliminary results of pressure profile measurements in our patients are much more accurate than those of other currently known measuring techniques. It is too early, however, to predict the extent of increased objectivity in the results of the new method for measuring urethral pressure profile, with and without functional electrical stimulation. The parameters of stimuli produced by our electrical stimulators will be based upon these findings

Plevnik S., Suhel P., Rakovec S., and Kralj B. (1977) Effects of functional electrical stimulation on the urethral closing muscles. *Med. Biol. Eng Comput.* 15, 155-167.

Plevnik S. and Janez J. (1979) Maximal electrical stimulation for urinary incontinence: report of 98 cases. *Urology* 14, 638-645.

Abstract: Ninety-eight patients with urinary incontinence have been treated with maximal electrical stimulation (MES) The MES method used is a modification of previously used similar methods of maximal stimulation with respect to reduced intensity of stimulation and reduced number of electrodes. Thus, discomfort to the patient during treatment is considerably lessened. Anal or vaginal MES produced temporary or sustained improvement or relief of incontinence in 47 of 98 patients

Plevnik S. (1983) Bladder stretch during increase in abdominal pressure. *Clin. Phys. Physiol Meas.* 4, 315-320.

Abstract: The circumference of single bladder projections (CBP) was estimated from oblique and lateral cystographs obtained in the supine and erect positions during both rest and straining, with and without electric stimulation of the pelvic floor. The results obtained indicate an increase of CBP and a flattening of the bladder during an increase of abdominal pressure, and a decrease of CBP during electrical stimulation. Increase of CBP means an increase in the stretching of the bladder wall, which may produce an increase in the forces in the bladder wall and hence act to open the bladder neck. The decrease of the CBP during electrical stimulation of the pelvic floor indicates that the pelvic floor support reduces flattening of the bladder and hence limits the development of the bladder wall stretch

Primus G. (1992) Maximal electrical stimulation in neurogenic detrusor hyperactivity: experiences in multiple sclerosis. *Eur. J. Med.* 1, 80-82.

Abstract: OBJECTIVES: We report our experiences with maximal tolerable electrical stimulation in neurogenic bladder dysfunction due to multiple sclerosis. METHODS: 27 female patients were treated with an intravaginal electrode carrier and an external pulse generator. The devices were individually adjustable with respect to electrode positioning and stimulation parameters. The frequency was 20 Hz. The threshold for sensation of the electrical stimulus was determined by slowly increasing the current and care was taken to stimulate with maximal tolerable stimuli. Urodynamic evaluation was done before and after cessation of treatment. RESULTS: During stimulation, 85% of the patients were free of symptoms. Three months after cessation of treatment only 18% remained free of symptoms, but the symptoms were not as pronounced as before treatment. CONCLUSION: Electrical stimulation using intravaginal electrodes represents a practical technical choice to treat motor urge incontinence in multiple sclerosis patients, although chronic stimulation is needed to retain improvement

Primus G. and Kramer G. (1996) Maximal external electrical stimulation for treatment of neurogenic or non-neurogenic urgency and/or urge incontinence. *Neurourol. Urodyn.* 15, 187-194.

Abstract: Maximal electrical stimulation by intravaginal or intra-anal electrodes was used for treatment of 75 patients with complaints of urgency and/or urge incontinence. The patient group consisted of 51 women and 24 men. A neurogenic background was present in 30 of the women who had a diagnosis of multiple sclerosis, in the other 45 patients the pathology was idiopathic in nature. After 3 weeks of maximal electrical stimulation treatment, composed of 15 sessions of 20

minutes duration, 59% of the patients had urodynamic and subjective improvement and an additional 40% only subjective improvement. One patient found no benefit after this treatment. The effect lasted for at least 2 years in 64% of the idiopathic group. In the multiple sclerosis group relapse occurred within about 2 months. Re-treatment of the failures was successful again immediately; the multiple sclerosis patients do need daily home stimulation treatments

Radil T. (1989) Evolutionary aspects of genito-urinal reflexes. *Med. Hypotheses* 30, 31-33.

Abstract: The favourable effect of vaginal electrical stimulation in patients with urinary incontinence may be caused by activation of ancient reflex mechanisms assuring mutually exclusive function of the female genital and urinary system linked to anatomical structures which were partially common during phylogenesis. Reciprocal inhibition of genital and urinary reflexes and of the corresponding behavior, assuring safe transport of the sperm to the egg, would represent an advantage greatly supported by selective pressure

Rakovec S. (1975) Reflex electrical stimulation for urinary incontinence. *Eur. Urol.* 1, 24-25.

Abstract: Experiments with several patients suffering from stress incontinence have shown that indirect stimulation of the levator ani with a vaginal stimulator and especially of the anal sphincter with an anal stimulator affects the urethral sphincter in the same way as direct stimulation. These findings are significant since they enable us to avoid the use of implantable stimulators by substituting external ones. External stimulation is worth trying in all cases of stress incontinence, where other conservative measures have failed. In our cases the results have been very satisfactory

Rakovec S. (1976) Reflex electrical stimulation for urinary incontinence. *Urol. Int.* 31, 111-123.

Abstract: Our previous observations have shown that the electrical stimulation of muscles is prevalently reflex. One of the advantages of reflex stimulation is that it activates not only a limited number of motor units, but rather a number of muscles connected by the same reflex from a single stimulation site. Consequently, it is not necessary to place electrodes into the muscle to be activated. They can be put elsewhere provided that the same effect is obtained and that it is more convenient for the patient. Such an opportunity arises when treating urinary incontinence which involves not only the urethral sphincter but also the group of synergistic muscles of the pelvic floor. Our experiments with several patients suffering stress incontinence have shown that indirect stimulation of the levator ani with a vaginal stimulator and especially of the anal sphincter with an anal stimulator affects the urethral sphincter in the same way as direct stimulation. These findings are significant since they enable us to use external instead of implantable stimulators. External stimulation is worth trying in all cases of stress incontinence where conservative measures have failed. In our cases, the results have been very satisfactory

Rakovec S., Plevnik S., and Kralj B. (1977) The mechanisms of the action of electrical stimulation of muscles. *Urol. Int.* 32, 232-237.

Abstract: The mechanisms of the action of electrical stimulation of muscles are discussed. We believe that the principal cause for the good results obtained in cases of stress incontinence with electrical stimulation must be due to the formation of a

better reflex in contraction of the muscles of the pelvic floor. This, however, involves changes at the level of the spinal cord. By the help of stimulation the patient learns to use the urethral sphincter and secondary forces of retention in a better and a more proper way. The good results obtained in the treatment of some cases of nocturnal enuresis by anal plugs require yet another explanation. It can be considered that in nocturnal enuresis the unconscious inhibition of the reflex mechanism for emptying the bladder is not developed enough. From the experience we know that vigorous voluntary activation of the muscles of the pelvic floor inhibits the contraction of the detrusor muscle. In this way it is possible to depress the urging sensation to urinate. In the paper we have tried to demonstrate this mechanism objectively. On the basis of our findings we believe that the good results in treating nocturnal enuresis may be due to this mechanism of stimulation

Ratani R.S., Yazaki E., Scott M., Pilot M.A., and Williams N.S. (1997) Electrically stimulated smooth muscle neosphincter. *Br. J. Surg.* 84, 1286-1289.
Abstract: BACKGROUND: Most patients undergoing total anorectal reconstruction suffer some degree of incontinence despite the incorporation of an electrically stimulated gracilis neosphincter. As smooth muscle has the ability to maintain prolonged contraction without fatigue, the aim of this study was to assess the feasibility of developing an electrically stimulated smooth muscle neosphincter. METHODS: Electrical stimulation of the rabbit colon was performed via intramural wire electrodes using a constant voltage DC stimulator. Contractile activity was recorded by serosal strain gauges and an intraluminal pressure probe. RESULTS: Basal colonic pressure was 4-13 (median 11) cmH₂O. Peak pressures generated by stimulated contractions (10 V, 1 ms, 10 Hz) ranged from 14 to 37 (median 26, n = 36) cmH₂O and were significantly higher than those with spontaneous contractions (P = 0.005). During continuous stimulation contractions lasted for 45-96 (median 74) s. Intermittent stimulation using trains of electrical pulses of 1-2-min duration at 1- 2-min intervals produced repeated contractions. Alternative contractions were produced when intermittent electrical stimulation was performed at two sites alternately with two pairs of electrodes more than 2.5 cm apart, producing a sustained high-pressure zone. CONCLUSION: An electrically stimulated smooth muscle neosphincter is feasible. It has potential applications in the management of faecal incontinence

Read D.J., James E.D., and Shaldon C. (1985) The effect of spinal cord stimulation on idiopathic detrusor instability and incontinence: a case report. *J. Neurol. Neurosurg. Psychiatry* 48, 832-834.
Abstract: A patient with long-standing symptoms of detrusor instability has been treated by electrical stimulation of the spinal cord. Stimulation abolished all symptoms and unequivocally inhibited episodes of instability

Reswick J.B. and Simoes N. (1975) Application of engineering principles in management of spinal cord injured patients. *Clin. Orthop.* 124-129.
Abstract: Engineering services currently being used for spine stabilization, respiratory assist, and pressure sore prevention are discussed as well as devices under development for bowel and bladder control, reduction of contractural deformities and spasticity, and electrical stimulation of paralyzed muscles. Concepts and devices for improved function are divided into categories of: orthotic devices; environmental control systems; mobility systems; page-turning devices. A wide range

of engineering devices are available but strict attention must be given to medical rationale for their use

Riabinskii V.S., Stepanov V.N., and Shadmanov A.K. (1990) [The combined treatment of urinary incontinence after adenomectomy]. *Urol. Nefrol. (Mosk)* 23-28.

Abstract: Treatment was applied in 55 patients with enuresis after removal of adenoma of the prostate. Nonoperative treatment of 46 patients included therapeutic exercises, drug therapy (anti-inflammatory agents and tonics), and physical methods: transurethral direct electrical stimulation of the vesical sphincters (25 patients), transperineal ultrasonic stimulation (21 patients). After nonoperative treatment enuresis was completely cured in 31 patients. Fifteen patients with poor results were subjected to a second course of treatment: a satisfactory result was produced in another 6 patients, an improvement was recorded in 9 patients. Operative treatment was carried out in 9 patients: 4 of them by A. Puigvert's method (satisfactory result in 1, improvement in 1, poor result in 1, acute ischuria in 1) and 5 by a modified Puigvert's operation the techniques of which consisted in forming 2 rectangular grafts from the tunica albuginea of the cavernous bodies of the penis, suturing the medial grafts to one another above the urethra on the midline, and suturing to their bases the lateral grafts (satisfactory results in 4, improvement in 1). Thus, complex treatment of 55 patients for enuresis consequent upon removal of adenoma of the prostate caused a satisfactory result in 42 (76.4%), an improvement in 11 (20%), and a poor result in 2 (3.6%) patients

Richardson D.A., Miller K.L., Siegel S.W., Karram M.M., Blackwood N.B., and Staskin D.R. (1996) Pelvic floor electrical stimulation: a comparison of daily and every- other-day therapy for genuine stress incontinence. *Urology* 48, 110-118.

Abstract: OBJECTIVES. To compare the effectiveness of daily and every-other-day electrical stimulation in treating genuine stress incontinence. METHODS. Subjects with genuine stress incontinence were enrolled in a multicenter, prospective, nonrandomized study and underwent daily or every-other-day pelvic floor stimulation treatments for 15 minutes twice a day. Outcome measures assessed were (1) leakage episodes and pad count; (2) leakage amount, and (3) subject subjective assessment and quality of life. Thirteen subjects treated daily and 15 treated every other day completed the 20-week protocol. One-year follow-up data were available for 21 subjects. RESULTS. No significant differences in primary outcome variables were found between the groups. Subjects treated every other day had significant decreases in total leakage episodes ($P = 0.04$), pad count ($P = 0.04$), total voids ($P = 0.02$), and visual analog scale scores, with stress incontinence cured or improved by 50% in 73% ($n = 11$). Subjects treated every day had significant decreases in urge episodes ($P = 0.03$), pad count ($P = 0.05$), and visual analog scale scores, with 62% ($n = 8$) cured or improved by 50%. Compliance was higher for subjects treated every other day ($P = 0.05$). Satisfaction with therapy was 75% ($n = 10$) for daily treatment and 77% ($n = 12$) for every-other-day treatment. At 1 year, 70% ($n = 7$) of subjects who continued device use maintained their cure or improvement status.

CONCLUSIONS. Both daily and every-other-day therapy with pelvic floor electrical stimulation are effective in treating genuine stress incontinence. Subjects who continue device use maintain a higher cure or improvement rate

Riedy L.W., Chintam R., and Walter J.S. (2000) Use of a neuromuscular stimulator to increase anal sphincter pressure. *Spinal Cord*. 38, 724-727.

Abstract: OBJECTIVES: The objective of this study was to determine if short periods

of electrical stimulation with perianal electrodes could increase anal pressures. MATERIAL AND METHODS: Anorectal responses to electrical stimulation were evaluated in five healthy SCI patients. Anorectal pressures were recorded with a small pressure-recording balloon before, during, and immediately following stimulation. A battery-powered stimulator with self-adhering surface electrodes, two inches in diameter was used. Stimulating parameters consisted of 300 microsecond pulse duration, 35 Hz stimulating frequency. A current response study was conducted by using short periods of electrical stimulating with currents from 0-100 mA until a maximal pressure was recorded. Each current setting was conducted for 13.2±9.7 s before increasing to the next higher current, and fatigue was reduced by including a 5-minute rest between stimulations. RESULTS: Four of the five subjects had strong anal contractions with perianal stimulation. Increases in pressure ranged from 38 to 125 cm H₂O based on maximal responses at current ranges of 60 to 100 mA. Even during the short periods of stimulation used here, fatigue was apparent. There was an average drop of 11% in anal pressure over the 13 s of stimulation. Rectal pressures were unchanged with perianal stimulation. CONCLUSIONS: Perianal stimulation with surface electrodes is an approach that might be considered in the future for management of fecal incontinence in individuals with spinal cord injury. Further studies are needed to assess the feasibility of using chronic perianal surface electrical stimulation to sustain anal sphincter contractions

Rijkhoff N.J., Wijkstra H., van Kerrebroeck P.E., and Debruyne F.M. (1997) Urinary bladder control by electrical stimulation: review of electrical stimulation techniques in spinal cord injury. *Neurourol. Urodyn.* 16, 39-53.
Abstract: Evacuation of urine in paraplegics without the need for catheters would be possible when voiding could be induced by eliciting a bladder contraction. A challenging option to obtain detrusor contraction is electrical stimulation of the detrusor muscle or its motor nerves. This article reviews the 4 possible stimulation sites where stimulation would result in a detrusor contraction: the bladder wall, the pelvic nerves, the sacral roots, and the spinal cord. With respect to electrode application, sacral root stimulation is most attractive. However, in general, sacral root stimulation results in simultaneous activation of both the detrusor muscle and the urethral sphincter, leading to little or no voiding. Several methods are available to overcome the stimulation-induced detrusor-sphincter dyssynergia and allow urine evacuation. These methods, including poststimulus voiding, fatiguing of the sphincter, blocking pudendal nerve transmission, and selective stimulation techniques that allow selective detrusor activation by sacral root stimulation, are reviewed in this paper

Rijkhoff N.J., Hendrikx L.B., van Kerrebroeck P.E., Debruyne F.M., and Wijkstra H. (1997) Selective detrusor activation by electrical stimulation of the human sacral nerve roots. *Artif. Organs* 21, 223-226.
Abstract: The purpose of this study was to investigate the feasibility of selective detrusor activation without activation of the urethral sphincter by sacral root stimulation in patients. The sacral roots were stimulated using a tripolar electrode. An anodal block was used to prevent the urethral sphincter from contraction. Using square current pulses (700 microseconds, 6-7 mA), no increase in intraurethral pressure was measured, while a normal increase in intravesical pressure occurred. The minimum pulse duration to obtain a complete block was 550 microseconds. The study shows that anodal blocking of action potentials is possible in humans and can result in selective detrusor activation when used in sacral root stimulation

Rogers J. (1992) Testing for and the role of anal and rectal sensation. *Baillieres Clin. Gastroenterol.* 6, 179-191.

Abstract: The rectum is insensitive to stimuli capable of causing pain and other sensations when applied to a somatic cutaneous surface. It is, however, sensitive to distension by an experimental balloon introduced through the anus, though it is not known whether it is the stretching or reflex contraction of the gut wall, or the distortion of the mesentery and adjacent structures which induces the sensation. No specific sensory receptors are seen on careful histological examination of the rectum in humans. However, myelinated and non-myelinated nerve fibres are seen adjacent to the rectal mucosa, but no intraepithelial fibres arise from these. The sensation of rectal distension travels with the parasympathetic system to S2, S3 and S4. The two main methods for quantifying rectal sensation are rectal balloon distension and mucosal electrosensitivity. The balloon is progressively distended until particular sensations are perceived by the patient. The volumes at which these sensations are perceived are recorded. Three sensory thresholds are usually defined: constant sensation of fullness, urge to defecate, and maximum tolerated volume. The modalities of anal sensation can be precisely defined. Touch, pain and temperature sensation exist in normal subjects. There is profuse innervation of the anal canal with a variety of specialized sensory nerve endings: Meissner's corpuscles which record touch sensation, Krause end-bulbs which respond to thermal stimuli, Golgi-Mazzoni bodies and pacinian corpuscles which respond to changes in tension and pressure, and genital corpuscles which respond to friction. In addition, there are large diameter free nerve endings within the epithelium. The nerve pathway for anal canal sensation is via the inferior haemorrhoidal branches of the pudendal nerve to the sacral roots of S2, S3 and S4. Anal sensation may be quantitatively measured in response to electrical stimulation. The technique involves the use of a specialized constant current generator and bipolar electrode probe inserted in the anal canal. The equipment is generally available and the technique has been shown to be an accurate and repeatable quantitative test of anal sensation

Rouanet P., Senesse P., Bouamirrene D., Toureille E., Veyrac M., Astre C., and Bacou F. (1999) Anal sphincter reconstruction by dynamic graciloplasty after abdominoperineal resection for cancer. *Dis. Colon Rectum* 42, 451-456.

Abstract: **PURPOSE:** Chronic low-frequency electrical stimulation can safely transform fatiguing muscle into fatigue-resistant muscle. This fundamental discovery was used to reconstruct the anal sphincter. Dynamic graciloplasty was found to be effective in the treatment of fecal incontinence. Our study was undertaken to investigate the oncologic, functional, and quality of life results of dynamic graciloplasty anal reconstruction after an abdominoperineal resection for carcinoma. **METHODS:** Between April 1993 and April 1996, nine patients (4 males) with a median age of 51.2 (range, 29-69) years underwent an abdominoperineal resection for carcinoma (4 had a rectal adenocarcinoma and 5 had an epidermoidal anal tumor) and an anal sphincter reconstruction with electrically stimulated graciloplasty. Oncologic and functional results were evaluated after a mean follow-up of 32 (range, 14-50) months. A quality of life questionnaire was filled out by seven patients. **RESULTS:** Sphincter reconstruction required the same hospitalization period as abdominoperineal resection. Two patients died from evolutive disease. Three patients were operated on twice, one for immediate colonic necrosis, two for colonic perforation after enema. One of them refused the graciloplasty and had an abdominoperineal resection. Six patients were dysfunctional. The mean resting pressure was 24 +/- 10 mmHg, and the mean pressure during stimulation was 95 +/-

25 mmHg. Five patients were continent for solids and liquid; four wore less than three pads per day, and one wore more than three. Four patients used enemas twice a week; one patient had spontaneous evacuation. The quality of life questionnaire showed that the mean scores for social interaction, symptoms, and psychological and physical states were 2.1, 2.2, 2.4, and 2.7, respectively. The mean value was 1.5. CONCLUSIONS: Total anorectal reconstruction with dynamic graciloplasty is an oncologically safe procedure. Functional results improve with time, but careful patient selection guarantees a successful functional outcome. Technical progress is necessary to improve the quality of life

Rudy D.C. and Woodside J.R. (1991) The incontinent myelodysplastic patient. *Urol. Clin. North Am.* 18, 295-308.

Abstract: Urinary incontinence is a socially devastating aspect of the lives of many myelodysplastic children. Incontinence results from abnormal bladder storage function, urethral sphincteric incompetence, or both. Unfortunately, the vesicourethral dysfunction in an individual patient cannot be discerned from the level of the vertebral defect or the coexisting neurologic deficits. Therefore, thorough urodynamic assessment is required to identify altered physiology precisely and to guide rational treatment. Our therapeutic armamentarium includes external devices, intermittent self-catheterization, pharmacologic therapy, prosthetics, electrical stimulation, biofeedback, and innovative surgical procedures. Comprehensive evaluation, thoughtful tailoring of therapy to the individual patient, and a commitment by the urologist to indefinite follow-up will enable most patients to attain social continence while preserving renal function

Rullier E., Zerbib F., Laurent C., Caudry M., and Saric J. (2000) Morbidity and functional outcome after double dynamic graciloplasty for anorectal reconstruction. *Br. J. Surg.* 87, 909-913.

Abstract: BACKGROUND: After abdominoperineal resection (APR), anorectal reconstruction with dynamic graciloplasty has been proposed to avoid abdominal colostomy and improve quality of life. Graciloplasties involving one or two gracilis muscles with various configurations have been described. The aim of this study was to evaluate morbidity and functional results in a homogeneous series of patients undergoing double dynamic graciloplasty following APR for rectal cancer. PATIENTS AND METHODS: From May 1995 to May 1998, 15 patients (ten men and five women; mean age 54 (range 39-77) years) underwent anorectal reconstruction with double dynamic graciloplasty after APR for low rectal carcinoma. All patients had preoperative radiotherapy (45 Gy), 11 with concomitant chemotherapy, eight had intraoperative radiotherapy (15 Gy) and ten received adjuvant chemotherapy for 6 months. The surgical procedure was performed in three stages: APR with coloperineal anastomosis and double graciloplasty (double muscle wrap); implantation of the stimulator 2 months later; and ileostomy closure after a training period. RESULTS: There was no operative death. At a mean of 28 (range 3-48) months of follow-up, there was no local recurrence; two patients had lung metastases. Early and late morbidity occurred in 11 patients, mainly related to the neosphincter (12 of 16 complications). The main complication was stenosis of the neosphincter (n = 6), which developed with electrical stimulation. Of 12 patients available for functional outcome, seven were continent, two were incontinent and three had an abdominal colostomy (two for incontinence, one for sepsis). Compared with patients without stenosis, patients with neosphincter stenosis required major reoperations (four versus zero) and had a poor outcome (two of six versus five of six

with a good result). CONCLUSION: The double dynamic graciloplasty is associated with a high risk of neosphincter stenosis, which may entail morbidity, reintervention and poor functional results. The stenosis is a heterogeneous feature of the neosphincter induced by asymmetrical traction of both gracilis muscles. It is suggested that single dynamic graciloplasty should be used for anorectal reconstruction after APR. Presented to the 101st congress of the Association Francaise de Chirurgie in Paris, France, October 1999, and to the European Council of Coloproctology in Munich, Germany, October-November 1999

Ruud Bosch J.L. and Groen J. (1996) Treatment of refractory urge urinary incontinence with sacral spinal nerve stimulation in multiple sclerosis patients. *Lancet* 348, 717-719.

Abstract: BACKGROUND: Urge urinary incontinence in multiple sclerosis patients is usually due to detrusor hyperreflexia. Patients who do not respond to conservative measures such as anticholinergics, with or without clean intermittent catheterisation, are difficult to manage. METHODS: We applied electrical stimulation to the S3 sacral spinal nerves with the aim of activating afferent somatic nerve fibres. Stimulation of these fibres can inhibit the micturition reflex. An S3 electrode coupled to a subcutaneously placed pulse generator was implanted in four women who had shown a good response during temporary stimulation via a percutaneously placed wire electrode. All patients were followed for at least 2 years. FINDINGS: The number of leakage episodes decreased from a mean of 4 to 0.3 per 24 h. Two patients were completely dry. The hyperreflexia disappeared in one, improved in two, and got worse in one patient. The urodynamic result in the last patient may be explained by clinical progression of the multiple sclerosis. INTERPRETATION: Chronic stimulation of the S3 sacral spinal nerve by an implantable neuroprosthesis is a promising treatment option for selected multiple sclerosis patients with refractory urge incontinence

Salinas C.J., Varela E., Prieto C.L., Virseda R.M., Salomon S., Guerrero A., and Pablo R.L. (1991) [Results of perineal electric stimulation in stress urinary incontinence]. *Arch. Esp. Urol.* 44, 437-440.

Abstract: The results achieved with perineal electrical stimulation in 25 patients with stress urinary incontinence of different etiology are presented herein. Overall, positive results were achieved in 52% and 28% were nonresponders. The results were positive in 66% with post- prostatectomy urinary incontinence. Before recurring to other more complicated therapeutic procedures, this treatment modality could be an alternative in the treatment of stress urinary incontinence

Salinas J., Tiraboschi R., Varela E., Vega A., Salomon S., Uson A., and Rodriguez L. (1990) [Treatment of bladder instability using intravaginal electric stimulation (intrarectal)]. *Arch. Esp. Urol.* 43, 523-526.

Abstract: Fourteen patients (13 females, 1 male) with urinary incontinence from bladder instability were treated with intravaginal (intrarectal) electrical stimulation. Good results were achieved in 57.1% of the cases. The foregoing finding shows that intravaginal (intrarectal) electrical stimulation may constitute a therapeutic option in urinary incontinence from bladder instability

Sand P.K., Richardson D.A., Staskin D.R., Swift S.E., Appell R.A., Whitmore K.E., and Ostergard D.R. (1995) Pelvic floor electrical stimulation in the treatment of genuine stress incontinence: a multicenter, placebo-controlled trial. *Am. J. Obstet. Gynecol.*

173, 72-79.

Abstract: OBJECTIVE: Our purpose was to determine the efficacy of transvaginal electrical stimulation in treating genuine stress incontinence. STUDY DESIGN: This was a multicenter, prospective, randomized, double-blind, placebo-controlled 15-week trial comparing the use of an active pelvic floor stimulator with a sham device. Thirty-five women used an active unit and 17 control subjects used sham devices. Weekly and daily voiding diaries were recorded throughout the trial. Urodynamic testing, including pad test and subtracted cystometry, was done before and at the end of device use. Pelvic muscle strength was measured at baseline and at the end of the trial. Patients scored their symptoms on visual analog scales and completed quality-of-life questionnaires before and after therapy. RESULTS: Significant improvements from baseline were found in patients using active devices but not in controls. Comparisons of changes from baseline between active-device and control patients showed that active-device patients had significantly greater improvement in weekly ($p = 0.009$) and daily ($p = 0.04$) leakage episodes, pad testing ($p = 0.005$), and vaginal muscle strength ($p = 0.02$) when compared with control subjects. Significantly greater improvement was also found for both visual analog scores of urinary incontinence ($p = 0.007$) and stress incontinence ($p = 0.02$), as well as for subjective reporting of frequency of urine loss ($p = 0.002$), and urine loss with sneezing, coughing, or laughing ($p = 0.02$), when compared with controls. Pad testing showed that stress incontinence was improved by at least 50% in 62% of patients using an active device compared with only 19% of patients using sham devices ($p = 0.01$). Voiding diaries showed at least 50% improvement in 48% of active-device patients compared with 13% of women using the sham device ($p = 0.02$). No irreversible adverse effects were noted in either group. CONCLUSIONS: Transvaginal pelvic floor electrical stimulation was found to be a safe and effective therapy for genuine stress incontinence

Sander P., Bjarnesen J., Mouritsen L., and Fuglsang-Frederiksen A. (1999) Anal incontinence after obstetric t. *Int. Urogynecol. J. Pelvic. Floor. Dysfunct.* 10, 177-181. Abstract: The study was a 1-year follow-up of 48 women with obstetric third- /fourth-degree perineal laceration. After primary surgical repair the symptomatic patients were treated with pelvic floor exercises with or without transanal electrical stimulation. Various methods for assessing anal sphincter function were also evaluated. One month postpartum 10 women (21%) complained of anal incontinence, 8 for flatus only; 1 patient was reoperated on. After 1 year none complained of fecal incontinence, and 3 (7%) complained of flatus incontinence. We found relatively few women with anal incontinence after t

Schiotz H.A. and Vormdal J. (1990) [Electrostimulation of the pelvic floor. A simple method of treating urinary incontinence]. *Tidsskr. Nor Laegeforen.* 110, 1372-1374. Abstract: Urinary incontinence is a very common condition affecting several hundred thousand Norwegian women. Traditional methods of treatment have often given unsatisfactory results, and many patients either do not seek help or are considered unsuitable for treatment. Electrical stimulation of the pelvic floor is a fairly new method of treating urinary incontinence. It is safe, simple, inexpensive and well tolerated. It cures or improves more than 50% of patients. More widespread use should save considerable amounts of money for the health services, and should improve the quality of life for many patients. It is recommended that electrostimulation therapy be made easily available in primary health care

Seim A., Hermstad R., and Hunskaar S. (1998) Female urinary incontinence: long-term follow-up after treatment in general practice. *Br. J. Gen. Pract.* 48, 1731-1734.
Abstract: BACKGROUND: Several reports have been published showing that women with urinary incontinence (UI) can be taken care of and treated satisfactorily in general practice. AIM: To find out whether the treatment of women with UI in general practice is effective also in the long term. METHOD: One hundred and five women with UI who consulted their general practitioner (GP) were examined and treated according to a treatment protocol. Treatment options were pelvic floor exercises, electrical stimulation, oestrogen supplements, bladder training, and protective pads. Three to six years after inclusion, all women received a postal questionnaire to evaluate the long-term effectiveness of treatment. Women who had been referred to a specialist were excluded. RESULTS: Eighty out of 82 eligible patients answered the questionnaire after a mean follow-up period of 56 months. Twenty-seven per cent were continent, 26% much better, 23% a little better, 21% unchanged, and 3% were worse compared with before the treatment. The median score on a 100 mm visual analogue scale was 16 compared with 31 before treatment, and the percentage of women that were 'much' or 'a great deal' bothered by UI was reduced from 35% to 12%. The percentage of women with severe UI was reduced from 59% to 30%, and the number of women using pads was reduced from 62% to 39%. CONCLUSION: This study confirms that management of female UI in general practice is effective also in the long term

Shanahan D.A., George B., Williams N.S., Sinnatamby C.S., and Riches D.J. (1993) The long head of the biceps femoris: anatomic basis for its possible use in the construction of an electrically stimulated neoanal sphincter. *Plast. Reconstr. Surg.* 92, 55-58.

Abstract: Electrical stimulation of the nerve to the gracilis muscle following its transposition around the anal canal creates an artificial sphincter capable of actively opposing intrarectal pressure. Not all patients have an available or suitable gracilis. This paper describes the anatomic basis for the use of the long head of the biceps femoris as a potential electrically stimulated neoanal sphincter. The muscle was found to have an adequate length and a suitable arc of rotation for transposition around the anal canal. In 75 percent of thighs studied the neurovascular anatomy of the long head of the biceps femoris was compatible with its utilization in this manner as an alternative to the gracilis

Siegel S.W., Richardson D.A., Miller K.L., Karram M.M., Blackwood N.B., Sand P.K., Staskin D.R., and Tuttle J.P. (1997) Pelvic floor electrical stimulation for the treatment of urge and mixed urinary incontinence in women. *Urology* 50, 934-940.
Abstract: OBJECTIVES: To determine the efficacy of daily or every-other-day electrical stimulation in treating detrusor instability (urge) or urge plus genuine stress (mixed) urinary incontinence in women. METHODS: A multicenter, prospective, nonrandomized study enrolled subjects with urge and mixed urinary incontinence assigned to daily or every-other-day treatments (15 minutes twice daily) using pelvic floor stimulation. Outcome measures assessed were (1) leakage episodes, nocturnal episodes, voiding frequency, total voids, and pad count, and (2) patient subjective assessment and quality of life. RESULTS: Seventy-two subjects were enrolled. Sixty-eight subjects completed the 20-week protocol: 33 treated daily and 35 treated every other day. The entire study group (n = 68) experienced a significant decrease in total leaks (P < 0.001), nocturnal episodes (P = 0.001), pad count (P = 0.002), and total voids (P = 0.003) and on visual analog scales. Sixty-nine percent (n = 46) of subjects

with urge or mixed incontinence were cured or improved by at least 50%, with 28% (n = 19) being cured. There were no significant differences between daily and every-other-day users. Nonresponse was correlated with number of previous therapies ($P < 0.001$) and number of vaginal deliveries ($P = 0.007$). Overall, subjects were 93% compliant with device use, and 72% (n = 47) were satisfied with the therapy. CONCLUSIONS: Twenty weeks of pelvic floor electrical stimulation therapy is effective in treating urge and mixed urinary incontinence, regardless of daily or every-other-day treatments

Smith J.J., III (1996) Intravaginal stimulation randomized trial. *J. Urol.* 155, 127-130.
Abstract: PURPOSE: The effectiveness of intravaginal electrical stimulation was compared to standard therapy in the treatment of genuine stress urinary incontinence and detrusor instability. MATERIALS AND METHODS: A total of 57 women with urinary incontinence was evaluated with video urodynamics and voiding diaries before and after treatment. Of the women 18 with stress urinary incontinence were randomized to electrical stimulation or Kegel exercise and 38 with detrusor instability were randomized to anticholinergic therapy or electrical stimulation. RESULTS: Of patients using electrical stimulation in the stress urinary incontinence group 66% improved and 72% of the patients with detrusor instability treated with electrical stimulation improved. These rates were not statistically significant when compared to traditional therapy. CONCLUSIONS: Electrical stimulation is safe and at least as effective as properly performed Kegel and anticholinergic therapy in the treatment of stress urinary incontinence and detrusor instability

Speakman C.T., Kamm M.A., and Swash M. (1993) Rectal sensory evoked potentials: an assessment of their clinical value. *Int. J. Colorectal Dis.* 8, 23-28.
Abstract: To assess abnormalities of sensory conduction in anorectal disease we have evaluated peripheral sensory perception and somatosensory evoked potentials produced by rectal stimulation in control subjects and patients with either constipation or idiopathic faecal incontinence. Evoked potentials were also recorded after posterior tibial and dorsal genital nerve stimulation. Rectal sensation was also assessed using electrical stimulation. Reproducible evoked potential recordings after anorectal stimulation were possible in only a minority of subjects and when recorded showed intersubject and intrasubject variation. In the constipated group there was a significant difference in rectal electrical sensation ($P < 0.05$) from controls. We conclude that peripheral sensory testing demonstrates an abnormality in severe constipation. However, cerebral evoked potentials cannot be reliably recorded after rectal stimulation, and when recorded the latencies are of too broad a range to discriminate between health and disease. This probably relates to the difference between somatic and visceral pathways

Speakman C.T. and Kamm M.A. (1993) Abnormal visceral autonomic innervation in neurogenic faecal incontinence. *Gut* 34, 215-221.
Abstract: Changes of denervation in the anal sphincter striated and smooth muscle in patients with neurogenic faecal incontinence are well established. This study aimed to determine if there is also a more proximal visceral autonomic abnormality. Thirty women with purely neurogenic faecal incontinence (prolonged pudendal nerve latencies and an intact sphincter ring) and 12 patients with neuropathic changes together with an anatomical disruption were studied. Two control groups consisted of 18 healthy volunteer women and 17 women with normal innervation but an anatomically disrupted sphincter. Rectal sensation was assessed using balloon

distension and electrical mucosal stimulation, and anal sensation by electrical stimulation. Rectal compliance was studied to determine whether sensory changes were primary or caused by altered rectal wall viscoelastic properties. Anal canal pressure changes in response to both rectal distension and rectal electrical stimulation were measured to assess the intrinsic innervation of the internal anal sphincter. Patients with neurogenic incontinence alone had impaired rectal sensation to distension (53.1 v 31.5 ml, $p < 0.05$, neurogenic v controls) and to electrical stimulation (24.4 v 14.8 mA, $p < 0.005$). Patients with neurogenic incontinence and sphincter disruption also showed impaired sensation compared with healthy controls (55.8 ml v 31.5 ml, $p < 0.05$ and 22.9 mA v 14.8 mA, $p < 0.05$). Patients with only a disrupted sphincter had normal visceral sensation to both types of testing. Both rectal compliance and the response of the internal anal sphincter to rectal distension and electrical stimulation were normal in all patient groups.(ABSTRACT TRUNCATED AT 250 WORDS)

Stein M., Discippio W., Davia M., and Taub H. (1995) Biofeedback for the treatment of stress and urge incontinence. *J. Urol.* 153, 641-643.

Abstract: Biofeedback and pelvic floor electrical stimulation are new modalities that have been advocated for the treatment of urinary incontinence. To evaluate the long-term effectiveness of biofeedback and identify factors predictive of a positive outcome, we prospectively studied 28 patients with stress and urge incontinence. All patients were evaluated with a complete history, physical examination, urinalysis and culture. Of 28 patients 21 were also studied with video urodynamics. Biofeedback was performed with the InCare PRS 8900* machine with each patient undergoing at least 6 office sessions. Quantifiable symptoms, such as frequency, nocturia and urgency, were evaluated before and periodically after treatment. Patients also graded the overall treatment response on a scale of 0 to 3. Biofeedback successfully treated 5 of 14 patients (36%) with stress incontinence and 9 of 21 (43%) with urgency incontinence. Treatment response was durable throughout followup in all responding patients. Additionally, there was a statistically significant decrease in daytime frequency and nocturia following biofeedback ($p = 0.038$ and $p = 0.044$, respectively). No pretreatment factors predictive of a positive outcome could be identified. Improvement in perineal muscle tone with time approached statistical significance. We conclude that biofeedback is a moderately effective treatment for stress and urge incontinence, and should be offered to patients as a treatment option. Few patients, however, choose biofeedback as a primary mode of therapy and, due to the availability of other highly successful treatments for stress urinary incontinence, it is unlikely to become a popular treatment option

Stuchfield B. (1997) The electrically stimulated neoanal sphincter and colonic conduit. *Br. J. Nurs.* 6, 219-224.

Abstract: Faecal incontinence affects about 2.2% of the population. Non-surgical interventions include dietary manipulation or the use of enemas and drug regimens. Surgical procedures such as anterior sphincter repair may improve function for the majority of patients, but for some a permanent stoma may be the only therapeutic option. A technique pioneered at the Royal London Hospital uses gracilis muscle augmentation combined with electrical stimulation to improve sphincter control. However, some patients experience residual evacuatory problems. Antegrade irrigation may be incorporated into the procedure, but both techniques can be used independently to promote continence. Although these procedures are still in a

developmental stage, they are an option for a select group of patients who would otherwise be managed with a permanent stoma

Suhel P. (1976) Adjustable nonimplantable electrical stimulators for correction of urinary incontinence. *Urol. Int.* 31, 115-123.

Abstract: Investigations of functional electrical stimulation (FES) of the closing muscles in the lower urinary tract using nonimplantable electrical stimulators have reached the final stage. The optimal stimuli parameters were chosen on the basis of neurophysiological studies of the urinary tract and urodynamic measurements of mechanical response to electrical stimulation. According to these findings, two electronic systems for FES have been developed. An adjustable system for stimulation of the urethral closing mechanism using vaginal or anal plugs. The external unit of the stimulator contains a generator producing square-wave pulses. The vaginal and anal plugs are from Vitalograph Ltd, and Cardiac Recorders Ltd., commercial types redesigned to suit our needs. Frequency and duration of the pulses can be individually adjusted for each patient. An automatic integrated adjustable system for stimulation of the urethral closing mechanism built into a vaginal plug. This stimulator is based on completely new design principles. It has the form of a cylinder with hemispherical ends. Both the electronic unit and battery supply are located within. The system is completely automatic and is started by placing the stimulator in the vagina. Both systems mentioned were constructed for curing stress incontinence, post-operative incontinence, enuresis and in some cases for use in incontinent paraplegics. Clinical evaluation has given satisfactory results for both types of stimulators in the above-mentioned patients. They are simple to use and instructions can be given in an urologist's prescription. Permanent or intermittent application is possible

Suhel P., Kralj B., and Plevnik S. (1978) Advances in nonimplantable electrical stimulators for correction of urinary incontinence. *TIT. J. Life Sci.* 8, 11-16.

Abstract: The nonimplantable electrical stimulators are widely used as rehabilitation aids for correction of urinary incontinence. The advances in the field of the design of nonimplantable electrical stimulators such as automatic vaginal electrical stimulator VAGICON-X and anal pressure controlled electrical stimulator are described. The evaluation of VAGICON-X in patients suffering from stress and urge incontinence as well as preliminary results of acute application of anal pressure electrical stimulation in patients with stress incontinence as presented

Sung M.S., Choi Y.H., Back S.H., Hong J.Y., and Yoon H. (2000) The effect of pelvic floor muscle exercises on genuine stress incontinence among Korean women--focusing on its effects on the quality of life. *Yonsei Med. J.* 41, 237-251.

Abstract: This study's purpose was to compare the treatment efficacy and the effects on the patients' quality of life of the pelvic floor muscle (PFM) exercise and the functional electrical stimulation (FES)- biofeedback method. Ninety female incontinence patients were randomly selected and evenly divided into three groups: control, intensive PFM exercise, and FES-biofeedback groups. They were treated for 6 weeks. The subjective changes in the severity of incontinence and discomfort in daily and social life were measured using a translated version of Jackson's Bristol female urinary symptom questionnaire. Objective changes of pelvic muscle contraction force were measured by perineometer. Pre and post-treatment maximal pelvic floor muscle contractile pressure (PMC pressure) among the three groups showed statistically significant differences ($p < 0.001$). Especially the FES-

biofeedback group showed significantly increased maximal PMC pressure compared with other groups ($p < 0.001$). From the questionnaire, pre and post-treatment changes in the severity of urinary incontinence and discomfort due to incontinence showed significant differences among the three groups ($p < 0.001$). The level of discomfort in daily life, social activity, physical activity, personal relations and discomfort due to urinary symptoms had largely changed and the FES-biofeedback group, in particular, showed a significant decrease after treatment. In conclusion, when PFM exercise and FES-biofeedback were compared in terms of their effects on the patients' quality of life, FES- biofeedback proved to be more effective than verbal explanation or simple PFM exercise

Sung M.S., Hong J.Y., Choi Y.H., Baik S.H., and Yoon H. (2000) FES-biofeedback versus intensive pelvic floor muscle exercise for the prevention and treatment of genuine stress incontinence. *J. Korean Med. Sci.* 15, 303-308.

Abstract: We undertook this work to compare the treatment efficacies and the changes of quality of life after pelvic floor muscle (PFM) exercise and the functional electrical stimulation (FES)-biofeedback treatment, both of which are being widely used as conservative treatment methods for female urinary incontinence. We randomly selected 60 female incontinence patients who visited our department and divided them evenly into two groups. They were treated for a period of 6 weeks. The subjective changes in the severity of incontinence and discomfort in daily and social life were measured using a translated version of the questionnaire by Jackson. Objective changes of pelvic muscle contraction force were measured using a perineometer. Pre- and post- treatment maximal pelvic floor muscle contractile (PMC) pressure and changes in the severity of urinary incontinence and discomfort of the two groups showed statistically significant differences ($p < 0.001$). In particular the FES-biofeedback group showed significantly increased maximal PMC pressure and a decreased severity of urinary incontinence and discomfort compared to the intensive PFM exercise group ($p < 0.001$). In conclusion, FES-biofeedback proved more effective than simple PFM exercise

Susset J., Galea G., Manbeck K., and Susset A. (1995) A predictive score index for the outcome of associated biofeedback and vaginal electrical stimulation in the treatment of female incontinence. *J. Urol.* 153, 1461-1466.

Abstract: A group of 64 women with stress incontinence alone (20), urgency incontinence (7) and mixed incontinence (37) were treated during 12 sessions, each 20 minutes long, during 6 weeks with combined alternating biofeedback and intravaginal electrical stimulation. Of the patients 21 had a complete recovery, 20 recovered sufficiently to avoid other forms of treatment and 23 failed to respond to the treatment. Thus, the overall success rate for this treatment was 64%. Various physiological parameters were collected from each patient before the start of the treatment sessions. Patient age, estrogen status, detrusor hyperreflexia, intravaginal pressure, percent transmission of the abdominal pressure to the urethra, degree of intrinsic sphincter deficiency and compliance with therapy were significant factors affecting the success of treatment. A statistical analysis was performed on these measurements to generate a score index model capable of predicting the outcome of a treatment consisting of associated biofeedback and electrical stimulation. We present a reliable method for distinguishing between patients who will and will not respond to this form of treatment. The most significant variables predictive of a good reduction outcome are patient age, presence of estrogen, absence of detrusor

instability and intrinsic sphincter deficiency, low urethral hypermobility and, most of all, compliance with treatment

Takiuchi H., Sakurai T., Tsujimoto Y., Sugao H., and Nakamura M. (1987) [A case of solitary pelvic kidney with vesicoureteral reflux and neurogenic bladder dysfunction]. *Hinyokika Kyo* 33, 75-78.

Abstract: A case of solitary pelvic kidney with neurogenic bladder dysfunction with vesicoureteral reflux is presented. The patient was a 15-year-old boy with sacral vertebral dysplasia and hare-lip, and he has been complaining of recurrent fever episodes and urinary incontinence since 11 years old. Renal anomaly was confirmed by DIP, CT and angiography, and grade IV vesicoureteral reflux was demonstrated by voiding cystourethrography. On cystometrography, low compliance bladder which had a 70 ml capacity on first desire to void and 90 ml capacity on maximum desire to void was observed. Electromyography of anal sphincter performed with uroflowmetry revealed no relaxation of external sphincter during voiding. To preserve renal function, antireflux surgery was performed by Cohen's method, and a successful result, that is cessation of reflux and no ureteral obstruction, was achieved. After operation, periodic transcutaneous electrical stimulation were applied to the pudendal nerve, as a result bladder capacity increased to 150 ml and dysuria with incontinence improved

Tanagho E.A., Schmidt R.A., and Orvis B.R. (1989) Neural stimulation for control of voiding dysfunction: a preliminary report in 22 patients with serious neuropathic voiding disorders. *J. Urol.* 142, 340-345.

Abstract: Our experience with electrode implantation has demonstrated that the most successful combination to achieve continence and promote bladder evacuation is implantation on the ventral component of S3 or S4 and extensive dorsal rhizotomy with selective peripheral neurotomy. Of 22 patients with serious neuropathic voiding disorders treated during the last 6 years results were available for evaluation in 19 (2 were lost to followup and 1 was withdrawn from the protocol because of an infection at the receiver site). In 8 patients (42 per cent) complete success was achieved. These patients have regained reservoir function, are completely dry and void with electrical stimulation. The voiding is synchronous, with low voiding pressure and low residual urine volumes. Ten patients qualify as having partial success. They have regained reservoir function and are dry. One patient voids partially with stimulation, 5 depend on intermittent self-catheterization, 1 regained reservoir function and received an artificial sphincter, and 3 are catheter-dependent (these 3 all had been incontinent preoperatively despite continuous catheter drainage). The remaining patient entered the program long after a cerebrovascular accident and treatment has failed owing to poor selection. The stimulation parameters, once stabilized, did not need to be increased, and neither the surgical manipulation of the sacral roots nor the electrode implantation resulted in further neural loss in any patient

Tanagho E.A. (1990) Electrical stimulation. *J. Am. Geriatr. Soc.* 38, 352-355.

Tjelum K.B., Lose G., Abel I., and Pedersen L.M. (1994) [Electrostimulation of the pelvic floor muscles in urinary incontinence]. *Ugeskr. Laeger* 156, 2214-2216.

Abstract: External electrical stimulation is a simple, noninvasive and inexpensive treatment modality, which is useful in the treatment of st

Trontelj J.V., Janko M., Godec C., Rakovec S., and Trontelj M. (1974) Proceedings: Electrical stimulation for urinary incontinence: a neurophysiological study. *Urol. Int.* 29, 213-220.

Trsinar B. and Kraij B. (1996) Maximal electrical stimulation in children with unstable bladder and nocturnal enuresis and/or daytime incontinence: a controlled study. *Neurourol. Urodyn.* 15, 133-142.

Abstract: The aim of this study was to investigate clinical and urodynamic effects of anal MES in children with unstable bladder and micturition problems (nocturnal enuresis and/or daytime incontinence). Seventy- three girls, aged 5 to 17 years, mean age 9.7 years, with cystometrically proved idiopathic detrusor instability and nocturnal enuresis and/or daytime incontinence, were treated by maximal electrical stimulation (MES) for 1 to 2 months. Twenty-one girls, aged 6 to 14 years, mean age 9.3 years, with unstable bladder and micturition problems used only the anal plug without a battery for 1 month and served as the control group. Four and a half months (1-36 months) after the end of treatment, 75% of the stimulated patients were cured or improved by 50% or more. In the control group, 86% of the girls remained unchanged ($P < 0.01$). One month after the completion of anal MES the average number of monthly nocturnal enuretic episodes fell from 14 to 6.5 ($P < 0.001$) and the number of daytime incontinence episodes diminished from 3 to 0 ($P < 0.001$). On an average of 14.5 months after the end of anal MES, enuresis recurred in 20% of cases. Post-MES cystometry showed intensified first desire to void ($P = 0.05$), as well as an increase in maximum cystometric capacity ($P < 0.0001$), bladder compliance ($P < 0.0001$), and volume of the first detrusor contraction ($P < 0.01$). A statistically significant decline in the number of uninhibited contractions was also noticed ($P < 0.001$). In the control group, the anal plug did not produce any significant cystometrical changes. Anal MES can be recommended as an effective method for treating nocturnal enuresis and/or daytime incontinence and unstable bladder in children

Vahtera T., Haaranen M., Viramo-Koskela A.L., and Ruutiainen J. (1997) Pelvic floor rehabilitation is effective in patients with multiple sclerosis. *Clin. Rehabil.* 11, 211-219.

Abstract: OBJECTIVE: To determine the effect of pelvic floor muscle exercises combined with electrical stimulation of pelvic floor on lower urinary tract dysfunction in multiple sclerosis (MS) patients with near normal (# 100 ml) postvoid residual volumes. DESIGN: Open, controlled, randomized study in two parallel groups. SETTING: Rehabilitation centre for MS patients. SUBJECTS: Fifty women and 30 men with definite MS and current symptoms of lower urinary tract dysfunction. OUTCOME: The muscle activity of the pelvic floor muscles was tested using surface EMG. Subjective urinary symptoms were assessed using a questionnaire. INTERVENTIONS: Pelvic floor muscles were stimulated using electrical stimulation at six sessions. During and after the final session the patients were taught to exercise their pelvic floor muscles and advised to continue these exercises regularly for at least six months. The control group was not treated. RESULTS: The maximal contraction power and endurance of the pelvic floor muscles increased after six sessions of electrical stimulation with interferential currents. Symptoms of urinary urgency, frequency and incontinence were significantly less frequent in the treated group than in the untreated subjects. Male patients appeared to respond better to the treatment than female patients. Compliance with the pelvic floor exercises was over 60% at the end of a follow-up for six months. Most drop-outs were due to the

disappearance of urinary tract symptoms or to severe relapses in MS.

CONCLUSIONS: The present study indicates that pelvic floor muscle exercises combined with electrical stimulation of the pelvic floor constitute an effective treatment for lower urinary tract dysfunction at least in male patients with MS

van Kerrebroeck P.E. (1998) The role of electrical stimulation in voiding dysfunction. *Eur. Urol.* 34 Suppl 1, 27-30.

Abstract: Different forms of dysfunction of the lower urinary tract can be treated with electrical stimulation. Currently, two operative treatment modalities are available. In patients with spinal cord injury the combination of posterior sacral root rhizotomies with implantation of electrodes on the anterior roots produces excellent results in terms of restoration of continence and bladder evacuation. In patients with chronic problems of urge incontinence, urgency/frequency and voiding dysfunction, neuromodulation of a sacral nerve with an implantable system can reduce the symptomatology significantly. Both these treatments are a valuable addition to the modern neuro-urological practice

Varma J.S. (1992) Autonomic influences on colorectal motility and pelvic surgery. *World J. Surg.* 16, 811-819.

Abstract: The nervous control of the motility of the human distal bowel was investigated by two physiological studies of electrical stimulation of sacral parasympathetic outflow in patients with high spinal injuries and in patients with intractable constipation following pelvic surgery. Identical and reproducible motility responses of the left colon, rectum, and anal sphincters were obtained by sequential electrical stimulation of anterior sacral roots S2, S3, and S4 in patients with spinal injury. S2 stimulation provoked isolated low-pressure colorectal contractions. S3 stimulation initiated frequency-dependent high-pressure colorectal motor activity which appeared peristaltic and was enhanced with repetitive stimuli. S4 stimulation increased colonic and rectal tone. Quantitative responses were maximal at the splenic flexure and rectum. Pelvic floor activity was stimulated in increasing magnitude from S2 to S4. These results of distal bowel motility were achieved by an implanted Brindley stimulator. A newer generation of externally active stimulators are envisaged for the control of lower bowel in fecal incontinence. Women with intractable constipation following hysterectomy had significantly increased rectal volume and compliance together with deficits of rectal sensory function. Following stimulation with Prostigmine (neostigmine) a colorectal motility gradient was paradoxically reversed in the patients following hysterectomy, thus constituting a functional obstruction. Denervation supersensitivity was demonstrable in 2 patients tested with carbachol provocation. These findings suggest dysfunction in the autonomic innervation of the hindgut in some patients following hysterectomy

Vereecken R.L., De Meirsmen J., Puers B., and Van Mulders J. (1982)

Electrophysiological exploration of the sacral conus. *J. Neurol.* 227, 135-144.

Abstract: Evoked urethral and anal responses are produced by electrical stimulation of penis, bladder neck and anus. Latency and duration of the responses after bladder neck and anal stimulation are greatly dependent on stimulus parameters, suggesting a polysynaptic reflex; penile stimulation probably involves an oligosynaptic pathway. In pathological conditions the responses are delayed and their duration reduced

- Visco A.G. and Figuers C. (1998) Nonsurgical management of pelvic floor dysfunction. *Obstet. Gynecol. Clin. North Am.* 25, 849-65, vii.
 Abstract: In the 50 years since pelvic muscle exercises were introduced for the nonsurgical management of pelvic floor dysfunction related to parturition, a variety of approaches have been introduced and the scope of indications has grown. This article describes the evaluation of patients with pelvic floor complaints, discusses additional techniques for performing pelvic muscle exercises including biofeedback and electrical stimulation, details a comprehensive educational program, and examines the literature on the use of pelvic muscle exercises for the treatment of stress and urge urinary incontinence
- Vodusek D.B. and Zidar J. (1987) Pudendal nerve involvement in patients with hereditary motor and sensory neuropathy. *Acta Neurol. Scand.* 76, 457-460.
 Abstract: Pudendal nerve involvement was demonstrated by electromyography of perineal muscles and by recordings of their direct and reflex responses on perineal electrical stimulation in 10 patients with hereditary motor and sensory neuropathy. Patients reported no defecation disturbances and the 6 men had good erections. Urinary stress incontinence was seen in those 2 (of 4) female patients who had delivered
- Walker J.M. (1998) Curricular content on urinary incontinence in entry-level physical therapy programmes in three countries. *Physiother. Res. Int.* 3, 123-134.
 Abstract: BACKGROUND AND PURPOSE: Urinary incontinence (UI) is a significant psychological, social and healthcare problem across the lifespan. Although there is evidence of physical therapy (PT) efficacy, no literature was located pertaining to UI in PT curricula. The aim was to compare curricular content on UI (of non-neuropathic origin) in PT programmes in Canada, the UK and the USA. The study subjects were PT educators in entry-level programmes. METHODS: All Canadian PT programmes (13) were surveyed. Stratification was used to make random samples of PT programmes: 50% of UK (13/26) and 50% of USA (69/136). A questionnaire was used to obtain information on: degree level, programme length, specific courses, time allotted, UI topics, teaching method(s), the professional teaching patients with UI and reasons for non-inclusion in the study. One follow-up letter was sent. Results are presented as frequencies and percentages. RESULTS: Overall, the response rate was 62.8%; country response rates were: Canada 92.3%; UK 76.9% and USA 53.6%. UI was taught in 80% of Canadian, 90% of UK (which gave the most time to teaching on UI: 70% > 60 minutes) and 78.4% of USA PT programmes. Kegel exercises were taught in all three countries (> 81.1%) and electrical stimulation in > 65%. Theory only was the primary method of teaching in all countries (> 64.9%). Physical therapists were reported to have a major role in treating patients with UI (Canada > 75%; UK 100%; USA 70.3%). CONCLUSIONS: With Kegel exercises and electrical stimulation taught in two-thirds of all programmes physical therapy graduates may have some knowledge of UI management. However, for the UK and USA programmes data are from only 38.5% and 27% respectively. As the common method of teaching on UI was by theory only, graduating physical therapists may lack the clinical skills to apply assessment and treatment techniques

- Wall L.L. (1993) Medical management of pelvic relaxation. *Curr. Opin. Obstet. Gynecol.* 5, 440-445.
 Abstract: Although most gynecologists consider surgery to be the treatment of choice for pelvic relaxation, there are many non-surgical forms of therapy for this problem

and conditions which it may produce, such as urinary incontinence. This review highlights the importance of properly diagnosing co-existent factors which may complicate a patient's condition, and reviews therapies which may relieve her discomfort without surgery. These options include manipulation of concurrent medical factors, estrogen therapy, pelvic muscle rehabilitation through exercise and electrical stimulation, prompted voiding regimens, and the use of supportive pessaries

Walters M.D., Realini J.P., and Dougherty M. (1992) Nonsurgical treatment of urinary incontinence. *Curr. Opin. Obstet. Gynecol.* 4, 554-558.

Abstract: Genuine stress urinary incontinence can be treated by surgical or nonsurgical methods. Conservative treatments include pelvic muscle exercises, hormonal and nonhormonal pharmacologic therapy, and functional electrical stimulation with vaginal or anal electrodes. All of these methods improve or cure stress incontinence in a significant proportion of selected women, with less cost and morbidity. Patients with genuine stress incontinence generally should have a trial of conservative therapy before corrective surgery is offered. Behavioral and pharmacologic methods, alone and in combination, are used for women with detrusor instability. Behavioral regimens, including bladder retraining and biofeedback, are particularly effective for urge and stress incontinence, but are dependent on compliance and motivation of both patient and caregiver. Drug therapy is effective, but with potential morbidity. As with genuine stress incontinence, surgical methods should only be employed for patients with detrusor instability who do not respond to nonsurgical treatment

Weinberger M.W., Goodman B.M., and Carnes M. (1999) Long-term efficacy of nonsurgical urinary incontinence treatment in elderly women. *J. Gerontol. A Biol. Sci. Med. Sci.* 54, M117-M121.

Abstract: BACKGROUND: Although urinary incontinence affects up to 35% of community-dwelling elderly women, the long-term efficacy of conservative treatment in this population is unknown. METHODS: Between April 1991 and January 1994, 81 community-dwelling women over age 60 underwent nonsurgical incontinence treatment that included pelvic muscle exercises, bladder retraining, estrogen replacement, biofeedback, functional electrical stimulation, and pharmacologic therapy. Information about intercurrent medical problems, urogynecologic diagnoses, treatment recommendations, and provider- documented outcome were collected from medical records. We mailed structured questionnaires evaluating persistent incontinence, treatment efficacy, interval therapy, and quality of life to women who had last attended clinic at least one year previously. RESULTS: Fifty-three of 81 (65%) women, mean age (+/- SD) 76 +/- 8 years, returned the questionnaire. The mean follow-up interval was 21 +/- 8 months. At follow-up, 43% of women reported incontinence was not a problem or mild, 33% reported moderate incontinence, and 21% reported severe incontinence. When patients compared their initial with current incontinence severity, improvement was significant ($p < .01$). Genuine stress incontinence was diagnosed in 18 women, detrusor overactivity in 14, and mixed incontinence in 13. Improvement did not vary consistently by incontinence diagnosis. Older patients had more severe incontinence at presentation ($r = .94$, $p = .02$) and reported less improvement ($r = .97$, $p < .01$) than younger ones. However, the overall likelihood of improvement was greatest among patients with the most severe incontinence at presentation ($r = .534$, $p < .001$). Subjects considered pelvic muscle exercises, delayed voiding, and caffeine restriction most effective in reducing

incontinence severity. CONCLUSIONS: Elderly women derive long-term clinical benefit from nonsurgical incontinence therapy. Younger patients and those with more severe incontinence are most likely to respond to treatment

Weiss B.D. (1991) Nonpharmacologic treatment of urinary incontinence. *Am. Fam. Physician* 44, 579-586.

Abstract: Standard therapy for urinary incontinence often includes pharmaceutical agents that carry a risk of side effects or interactions with other drugs. As an alternative, several nonpharmacologic management approaches are available. Scheduled voiding regimens are effective for patients who have uninhibited detrusor contractions, even when cognitive impairment is present. In motivated patients, pelvic muscle exercise is effective for stress incontinence. These methods are safe and inexpensive, and studies indicate that they can be as effective as or more effective than pharmaceutical agents. Other nonpharmacologic approaches to management include biofeedback techniques and electrical stimulation therapy

Wexner S.D., Gonzalez-Padron A., Teoh T.A., and Moon H.K. (1996) The stimulated gracilis neosphincter for fecal incontinence: a new use for an old concept. *Plast. Reconstr. Surg.* 98, 693-699.

Abstract: The stimulated gracilis neosphincter is a viable procedure in selected patients with fecal incontinence. The aim of this paper is to review the technique of this staged operative procedure and review the problems and complications. Stage 1 consists of the vascular "delay" of the gracilis muscle and the creation of a temporary stoma. Stage 2 consists of transposition of the muscle around the anus with implantation of the stimulator. Low-frequency electrical stimulation is applied to the muscle for 12 weeks, after which stage 3 (stoma closure) is undertaken. From March of 1993 to March of 1995, 14 patients (9 females and 5 males) with a mean age of 44 years (range 20 to 67 years) underwent the procedure. Two patients died within 1 year of the operation from unrelated causes. Two patients developed anal stenosis and required permanent stomas. Other complications noted during ascent of the learning curve included seroma, excoriation of the skin above the stimulator, transposition of the stimulator, premature battery discharge, wound infection, rupture of the gracilis tendon, fatigue during programming sessions, and electrode displacement or fibrosis from the nerve. However, 8 of the 10 eligible patients had stoma reversal; the manometric results showed an average mean squeeze pressure that increased from 43 mmHg prior to surgery to 151 mmHg after the operation ($p < 0.01$). Based on an objective functional questionnaire, 60 percent of the patients who could be evaluated reported improvement in continence, social interactions, and the quality of their life. In conclusion, despite a steep learning curve, the stimulated gracilis operation is a viable operation for selected patients with severe incontinence

Wexner S.D., Gonzalez-Padron A., Rius J., Teoh T.A., Cheong D.M., Noguerras J.J., Billotti V.L., Weiss E.G., and Moon H.K. (1996) Stimulated gracilis neosphincter operation. Initial experience, pitfalls, and complications. *Dis. Colon Rectum* 39, 957-964.

Abstract: PURPOSE: The stimulated gracilis neosphincter is accepted as a viable option in select patients with fecal incontinence. The aim of this study was to review the initial problems and complications. METHODS: A prospective analysis of all patients who underwent this procedure was undertaken. Stage I consisted of the distal vascular delay of the muscle and creation of a temporary stoma. Stage II was the transposition of the muscle and implantation of the stimulator and electrodes.

Low frequency electrical stimulation was applied to the muscle for 12 weeks, after which Stage III (stoma closure) was undertaken. RESULTS: From March 1993 to December 1995, 17 patients (9 females and 8 males) with a mean age of 42.2 (range, 19-72) years underwent the procedure. One patient died from pancreatitis and another from small-bowel adenocarcinoma, three and six months after the procedure, respectively. Two patients (one with Crohn's disease) required permanent stomas. One additional patient required a permanent stoma because of lead fibrosis. Other complications noted during ascent of the learning curve included seroma of the thigh incision, excoriation of the skin above the stimulator, fecal impaction, anal fissure, parastomal hernia, rotation of the stimulator, premature battery discharge, fracture of the lead, perineal skin irritation, perineal sepsis, rupture of the tendon, tendon erosion, muscle fatigue during programming sessions, and electrode displacement from the nerve or fibrosis around the nerve. However, ultimately after rectification of these problems, 13 of the 15 eligible patients had stoma reversal. Manometric results showed an average basal pressure of 43 mmHg and an average maximum squeeze pressure that increased from 36 mmHg before surgery to 145 mmHg by stimulation ($P < 0.01$). Based on objective functional questionnaires, 9 of 15 (60 percent) evaluable patients reported improvement in continence, social interactions, and quality of life. Three of these nine patients require daily use of enemas. CONCLUSION: Although the stimulated gracilis operation is a feasible procedure for selected patients with severe incontinence, the learning curve is steep. Although the ultimate outcome in a selected group of patients can be very gratifying, major technical modifications are required before use beyond a research protocol setting. Furthermore, patients must have the psychological strength, emotional commitment, and financial resources that may be necessary for multiple revisional surgeries or ultimate device failure

Williams N.S., Patel J., George B.D., Hallan R.I., and Watkins E.S. (1991) Development of an electrically stimulated neoanal sphincter. *Lancet* 338, 1166-1169.
Abstract: In early surgical attempts to create a neoanal sphincter for patients who are faecally incontinent, skeletal muscle (usually the gracilis) has been transposed around the anal canal. Despite modifications, such as intermittent electrical stimulation, this procedure is likely to fail because the fast-twitch gracilis muscle is incapable of prolonged contraction without fatigue. Long-term electrical stimulation to convert such a muscle to a slow-twitch, fatigue-resistant muscle, though practicable, has yielded inconsistent results. We describe further modifications of this technique. A neoanal sphincter was constructed with an electrically stimulated transposed gracilis muscle in 20 incontinent patients with a deficient anal sphincter, and as part of a reconstruction in 12 patients in whom the anorectum had been excised or was congenitally absent. A totally implanted stimulator was used to convert the muscle from a fast-twitch to a slow-twitch muscle. Other modifications included vascular delay 4-6 weeks before transposition of the muscle, stimulation of the main nerve to the gracilis rather than its peripheral branches, and intermittent higher frequency stimulation. 2-4 of these modifications gave significantly fewer failures than did 0-1. With the new technique, continence has been restored in patients whose only other treatment option was a permanent stoma

Wise B. and Cardozo L. (1991) Urge incontinence and stress incontinence. *Curr. Opin. Obstet. Gynecol.* 3, 520-527.
Abstract: Urinary incontinence remains a common problem that adversely affects the quality of life of millions of women. In detrusor instability, treatment measures often

lack efficacy or are accompanied by unacceptable side effects. In this review, standard treatments are discussed, together with recent pharmacologic advances and the introduction of newer techniques including maximal electrical stimulation. The nonsurgical treatment options currently available for genuine stress incontinence are considered in the light of recent advances

- Wright A.L., Williams N.S., Gibson J.S., Neal D.E., and Morrison J.F. (1985) Electrically evoked activity in the human external anal sphincter. *Br. J. Surg.* 72, 38-41.
Abstract: Following electrical stimulation of perianal skin, short latency evoked electromyographic (EMG) responses from the external and sphincter have been interpreted as the electrophysiological correlate of the anal reflex. Delayed responses in patients with idiopathic faecal incontinence have been interpreted as evidence for denervation of the external anal sphincter. Electrically evoked responses were studied in normal subjects, either before and during spinal anaesthesia (n = 8), or before and during competitive neuromuscular blockade (n = 4), instituted for operative purposes. Short latency responses persisted unchanged in either latency or duration during spinal anaesthesia whereas long latency responses were completely abolished. Both short and long latency responses were abolished during competitive neuromuscular blockade. Short latency responses are not spinal reflex in nature, but due to stimulus activation of alpha-motoneuronal terminal branches. Delayed responses in incontinent patients cannot be interpreted as evidence for pudendal neuropathy. Long latency (i.e. greater than 40 ms) responses demand a functional sacral spinal cord and represent the true anal reflex. Their wide range of latency in normal subjects suggests this measurement will be of little use in confirming the presence or absence of pudendal neuropathy, and that other measures of neuropathy may be more appropriate
- Wyman J.F. (1993) Managing urinary incontinence with bladder training: a case study. *J. ET Nurs.* 20, 121-126.
Abstract: Bladder training is a simple, safe, and effective treatment in the management of mild to moderate forms of urinary incontinence in outpatient populations. It can be used as a first-line treatment or in combination with such other interventions as pelvic muscle exercises, bladder pressure biofeedback, electrical stimulation, and drug therapy. This article describes the implementation of a 6-week bladder training program for a female patient with both stress and urge incontinence
- Yamanishi T., Yasuda K., Sakakibara R., Hattori T., Ito H., and Murakami S. (1997) Pelvic floor electrical stimulation in the treatment of stress incontinence: an investigational study and a placebo controlled double-blind trial. *J. Urol.* 158, 2127-2131.
Abstract: PURPOSE: We designed an investigational study and a placebo controlled, double-blind study to evaluate the usefulness of electrical pelvic stimulation in stress incontinence. MATERIALS AND METHODS: We studied 44 patients with stress incontinence (six men and 38 women, age 63 +/- 13), including 9 patients in the investigational study and 35 in the double-blind study. We used 50 Hz. square waves of 1 ms. pulse duration for stimulation. A vaginal electrode was used in women and an anal electrode in men. Urethral pressure profile before, during and after 15-minute stimulation was measured in the investigational study. In the double-blind trial an active device and a dummy device were used, and efficacy was judged from patient impressions, records in frequency/volume chart, results of 1-hour pad test and urodynamic parameters after 4-week treatment. RESULTS: In the investigational

study maximum urethral closure pressure (mean plus or minus standard deviation) before, during and after stimulation was 44.4 +/- 17.5, 64.5 +/- 28.8 and 46.8 +/- 25.6 cm. water, respectively. This parameter significantly increased ($p = 0.0275$) during stimulation. In the double-blind trial patient impressions were good in 60% of the active device group and 8% of the dummy device group ($p = 0.0051$). For the pad test significant improvement was noted in the active device group ($p = 0.0100$). Cure rate was 45% in the active device group and 7.7% in the dummy device group. There were significantly more cured or improved patients for frequency of leakage ($p = 0.0196$) and pad test ($p = 0.0100$). CONCLUSIONS: Electrical stimulation is effective for the treatment of stress incontinence

Yamanishi T. and Yasuda K. (1998) Electrical stimulation for stress incontinence. *Int. Urogynecol. J. Pelvic. Floor. Dysfunct.* 9, 281-290.

Abstract: Electrical stimulation has been reported to be effective for stress incontinence, cure and improvement rates being reported to range from 30% to 50%, and from 6% to 90%, respectively. However, clinical application of this treatment is not common because there is little physiological and technical information. Electrodes for electrical stimulation are divided into two types: external (non-implantable) and internal (implantable), and there are two methods of stimulation: chronic (long-term, continuous) and short-term. Frequencies of 20-50 Hz, with a pulse duration of 1-5 ms, have been reported to be effective for urethral closure. The effectiveness of the treatment should be verified with placebo-controlled double-blinded trials, and four such studies using an active and a sham device have been reported. Two of these verified the superiority of the active device over the sham device, but the others did not demonstrate any significant difference between the two with regard to efficacy. Electrical stimulation has been reported to result in a long-term continuation of therapeutic effect. The effect has been explained as a re-education or a reactivation of lost functions of the pelvic floor muscles. As to adverse effects, there may be some complications in relation to anesthesia or surgical procedures, such as infection, pain and bleeding with implantable electrodes. The incidence of adverse effects in short-term electrical stimulation is less than 14%. In conclusion, short-term electrical stimulation using non-implantable anal or vaginal electrodes is the most recommendable because of safety and ease of use

Yamanishi T., Sakakibara R., Uchiyama T., Suda S., Hattori T., Ito H., and Yasuda K. (2000) Comparative study of the effects of magnetic versus electrical stimulation on inhibition of detrusor overactivity. *Urology* 56, 777-781.

Abstract: OBJECTIVES: To perform a randomized comparative study investigating the urodynamic effects of functional magnetic stimulation (FMS) and functional electrical stimulation (FES) on the inhibition of detrusor overactivity. METHODS: Thirty-two patients with urinary incontinence due to detrusor overactivity (15 men, 17 women; age 62.3 +/- 16.6 years) were randomly assigned to two treatment groups (15 patients in the FMS group and 17 in the FES group). Stimulation was applied continuously at 10 Hz in both groups. For FMS, the magnetic stimulator unit was set on an armchair type seat and had a concave-shaped coil, so that the patients could sit during stimulation. For FES, a vaginal electrode was used in the women and a surface electrode on the dorsal part of the penis was used in the men. Cystometry was performed before and during the stimulation. RESULTS: The bladder capacity at the first desire to void and the maximum cystometric capacity increased significantly during stimulation compared with prestimulation levels in both groups ($P = 0.0054$ and 0.0026 , respectively, in the FMS group and $P = 0.0015$ and 0.0229 , respectively,

in the FES group). However, the increase in the maximum cystometric capacity was significantly ($P = 0.0135$) greater in the FMS group (114.2 +/- 124.1 mL or an increase of 105.5% +/- 130.4% compared with the pretreatment level) than that in the FES group (32.3 +/- 56.6 mL or an increase of 16.3% +/- 33.9%). Detrusor overactivity was abolished in 3 patients in the FMS group but not in any patient in the FES group. CONCLUSIONS: Although both treatments were effective, the inhibition of detrusor overactivity appeared greater in the FMS group than in the FES group

Yamanishi T., Yasuda K., Sakakibara R., Hattori T., and Suda S. (2000) Randomized, double-blind study of electrical stimulation for urinary incontinence due to detrusor overactivity. *Urology* 55, 353-357.

Abstract: OBJECTIVES: To evaluate the usefulness of electrical stimulation for urinary incontinence due to detrusor overactivity in a randomized, double-blind manner. METHODS: Sixty-eight patients (29 men, 39 women, 70.0 +/- 11.2 years) were studied. Detrusor overactivity was urodynamically defined as involuntary detrusor contractions of more than 15 cm H₂O during the filling phase. Ten-hertz square waves of 1- ms pulse duration were used. A vaginal electrode was used in the women and an anal or surface electrode in the men. The stimulation was given for 15 minutes twice daily for 4 weeks. The efficacy was evaluated on the basis of a frequency/volume chart and urodynamic study before and after treatment. RESULTS: Thirty-two patients in the active group and 28 in the sham group completed the study. The patient impressions were very good or good in 59% and 39% of the active and the sham group, respectively ($P = 0.0354$). On the cystometrogram, the bladder capacity at the first desire to void and the maximum desire to void increased significantly ($P = 0.0104$ and $P = 0.0046$, respectively) in the active group, but not in the sham group. Seven patients in the active group and 1 patient in the sham group were cured ($P = 0.0324$); 26 patients (81.3%) in the active group and 9 (32.1%) in the sham group improved ($P = 0.0001$). Of 17 patients in the active group, 13 remained cured or improved for an average of 8.4 months after completion of the 4-week treatment; in the sham group, 3 of 6 patients were cured or improved for an average of 4.7 months after completion of the 4-week treatment. CONCLUSIONS: Electrical stimulation was useful in treating urinary incontinence due to detrusor overactivity

Yokoyama O., Miyazaki K., Ishida T., Nango O., Fujita Y., Nagano K., Kawaguchi K., Koshida K., and Hisazumi H. (1992) [Experimental and clinical evaluation of functional electrical stimulation of the anal sphincter]. *Hinyokika Kyo* 38, 1109-1115. Abstract: To determine the most effective parameter of functional electrical stimulation of the anal sphincter (FES), the present study was carried out in female mongrel dogs anesthetized with alpha-chloralose urethane. When spontaneous and rhythmic micturition contractions of the bladder were present, they were more effectively inhibited by the stimulation with low frequency (5 to 10 Hz). Based on the results of this experiment 18 patients with urge incontinence were treated by maximal electrical stimulation with the following parameters. The duration for each stimulus was 0.2 msec, frequency 5 Hz, amplitude 30 to 150 volts. Every patient received ten treatments for two weeks, each lasting for 30 minutes. A clinical cure for urge incontinence was noted in 12 patients. As for urodynamic studies, FES increased significantly the volumes of the first desire to void (FDV) and maximum desire to void (MDV); however, it did not increase significantly the maximum urethral closure pressure or residual urine volume. Eighteen patients were divided into two groups; an unstable bladder group and a neurogenic bladder group. In the latter, the

increases in volumes of FDV and MDV were significant. Second, 18 patients were divided into two groups according to the administration of lack of anticholinergic agents. For subjective symptoms, the rate of improvement of urge incontinence was significantly higher in the group administered the agents. These findings suggested that FES was very useful for the treatment of urge incontinence, with its efficacy augmented by the administration of anticholinergic agents

Zollner-Nielsen M. and Samuelsson S.M. (1992) Maximal electrical stimulation of patients with frequency, urgency and urge incontinence. Report of 38 cases. *Acta Obstet. Gynecol. Scand.* 71, 629-631.

Abstract: Thirty-eight consecutive female patients with frequency, urgency or urge incontinence were treated with maximal electrical pelvic floor stimulation. Diagnostic cystometry was performed in 34 cases. Detrusor instability was found in 13 patients, sensory urgency in 13 and hyperreflexia in eight cases. The effect of the treatment was evaluated by subjective assessment and micturition charts filled in for 48 hours. 63% were cured or improved. The success rate was the same among elderly and younger patients. Detrusor instability and hyperreflexia improved in about 75% of the cases. A good correlation was found between the subjective assessment and the micturition chart recordings. Maximal electrical stimulation has a good effect on certain types of lower urinary tract dysfunction with few side-effects. It is well tolerated even by elderly patients

Zonnevillage E.D., Somia N.N., Abadia G.P., Stremel R.W., Maldonado C.J., Werker P.M., Kon M., and Barker J.H. (2000) Sequential segmental neuromuscular stimulation reduces fatigue and improves perfusion in dynamic graciloplasty. *Ann. Plast. Surg.* 45, 292-297.

Abstract: Dynamic graciloplasty is used as a treatment modality for total urinary incontinence caused by a paralyzed sphincter. A problem with this application is undesirable fatigue of the muscle caused by continuous electrical stimulation. Therefore, the neosphincter must be trained via a rigorous regimen to transform it from a fatigue-prone state to a fatigue-resistant state. To avoid or shorten this training period, the application of sequential segmental neuromuscular stimulation (SSNS) was examined. This form of stimulation proved previously to be highly effective in acutely reducing fatigue caused by electrical stimulation. The contractile function and perfusion of gracilis muscles employed as neosphincters were compared between conventional, single-channel, continuous stimulation, and multichannel sequential stimulation in 8 dogs. The sequentially stimulated neosphincter proved to have an endurance 2.9 times longer (as measured by halftime to fatigue) than continuous stimulation and a better blood perfusion during stimulation (both of which were significant changes, $p < 0.05$). Clinically, this will not antiquate training of the muscle, but SSNS could reduce the need for long and rigorous training protocols, making dynamic graciloplasty more attractive as a method of treating urinary or fecal incontinence