

Nerve Transfer to Restore Genital Sensation in Women with Low Spinal Lesion: The Female TOMAX Procedure

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Background: Women with spinal cord lesions have loss of sensation in the lower body, negatively affecting sexuality in many ways: decreased, lost, or changed genital sensation and difficulties with orgasm. Restoring genital sensation in men with low spinal lesions using a nerve transfer (to maximize sensation, sexuality, and quality of life [TOMAX] procedure) has shown the potential to enhance sexual functioning and satisfaction. This procedure was adapted to a female version, in which the dorsal clitoral nerve was transferred to the ilioinguinal nerve to restore genital sensation. We report the results of the first female TOMAX patients.

Methods: Four patients with spinal lesions below L1 with unilaterally or bilaterally absent genital sensations and normal sensation in the groin were included. All patients underwent both neurological and psychological assessments preoperatively and at 6, 12, and 18 months postoperatively.

Results: The mean patient age was 53.3 years. Three patients experienced sensations in the clitoris and labia minora at 18 months postoperatively, which led to orgasms in 1 patient. One patient gained no sensation in her genitals but had a surprising side effect: she did not have to catheterize herself anymore.

Conclusion: The female TOMAX procedure is a new promising technique for restoring sensation of the genitals in women with low spinal cord lesions. (*Plast Reconstr Surg Glob Open* 2024; 12:e6315; doi: [10.1097/GOX.0000000000006315](https://doi.org/10.1097/GOX.0000000000006315); Published online 12 November 2024.)

INTRODUCTION

Patients with spinal cord lesions (SLs) may experience several neurological dysfunctions. The severity and extent of these problems relates to the level and completeness of lesions. SL are seen in patients with spina bifida (SB), spinal cord injuries (SCIs), or cauda equina syndrome (CES). Loss of genital sensation negatively affects sexual life.¹ Most women with low SL have normal sexual desire and are sexually active, but loss of genital sensation can lead to difficulties in achieving orgasm.¹

Restoring genital sensation in low SL men, using nerve transfer, has the potential to enhance sexual

health, functioning, and satisfaction.^{2,3} In these patients, sensory transmission from the penis through the dorsal penile nerves (DNPs) and sacral roots to the sensory cortex is interrupted by the SL. If this lesion is below the level of L1, however, the sensory ilioinguinal nerve (IIN), which supplies the groin/medial thigh, will be functionally intact and usable in nerve transfer to the numb penis. In this so-called “to maximize sensation, sexuality, and quality of life (TOMAX) procedure”, the distally cut IIN is microsurgically connected to the proximally divided DNP at the base of the penis. In this new situation, penile sensory impulses are rerouted through the IIN to the brain, bypassing the SL.⁴

In a study of 27 patients, 80% regained unilateral glans penis sensation after a unilateral TOMAX procedure. Sensations were initially felt in the groin but transferred to the glans penis itself in 46% of patients.¹ Until 2018, however, 73 men underwent surgery, of which 77% (re)gained glans penis sensation, resulting in 58% increased overall satisfaction.⁵ Due to these positive results, female low SL patients wondered if restoring genital sensation (clitoris, clitoral hood, labia, and introitus) was also possible.

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The clitoris consists of a nonerectile tip, glans, and erectile bodies and is covered by a clitoral hood (fusion upper part the labia minora). The dorsal clitoral nerve (DCN) provides clitoral innervation bilaterally, which is a termination of the pudendal nerve (S2–4).⁶ In 3 cadaver dissections, this clitoral (neuro) anatomy was confirmed. We concluded that with some adaptations to the male surgical approach,⁷ it would be possible to transfer the IIN to the ipsilateral DCN (Fig. 1).

This study in women with a low SL was designed to show:

1. The feasibility of transferring the IIN to the DCN, thereby restoring (sexual) genital sensation.
2. Whether this sensation benefits the patient's sexual health.

We report the results of the first 4 female TOMAX patients.

METHODS

In this prospective pilot study, with ethical approval, 4 motivated female patients were selected with an SL below L1 with absent genital sensations (clitoris, clitoral hood, labia minora, and introitus) and a completely normal sensation in the groin. A single plastic surgeon performed the procedure. All patients underwent both neurological and simple psychosexual assessments preoperatively and at 6 and 12–18 months postoperatively.

Neurological Assessment

We used simple neurological sensory tests for touch (pointed versus blunt) and temperature [warm (37°C) versus cold (4°C)] bilaterally at the groin, inner thigh, labium majus, labium minus, clitoral hood, clitoris, and introitus. Postoperatively, in addition to the absence or

Takeaways

Question: Is it possible to restore genital sensation in women with a low spinal lesion with a nerve transfer?

Findings: We report the results of the first 4 female patients undergoing the to maximize sensation, sexuality, and quality of life (TOMAX) procedure, in which the dorsal clitoral nerve was transferred to the ilioinguinal nerve to restore genital sensation.

Meaning: The female TOMAX procedure is a promising new technique for restoring sensation of the genitals in women with low spinal cord lesions.

presence of sensation, the location at which sensation was experienced subjectively (groin, clitoris, or somewhere between these 2 regions) was documented.

Psychosexual Assessment

A short interview measured various aspects of sensation (present/absent, erogenous/tactile, and pleasant/painful), arousal, sexual activity (intercourse, masturbation), orgasm, lubrication, and bladder function/catheterization.

Surgical Technique

The unilateral procedure is done under general anesthesia. The right or left side is selected based on the combination of completely normal inguinal sensation and completely absent clitoral sensation on that side.

An inguinal incision over the course of the IIN extends caudally along the lateral margin of the large labium. The IIN is identified underneath the external oblique fascia and dissected as distally as possible.⁷ The second incision starts at the level of the clitoris caudally along the lateral border of the major labium. Deepening the incision caudally reveals the inferior pubic ramus. Here, the

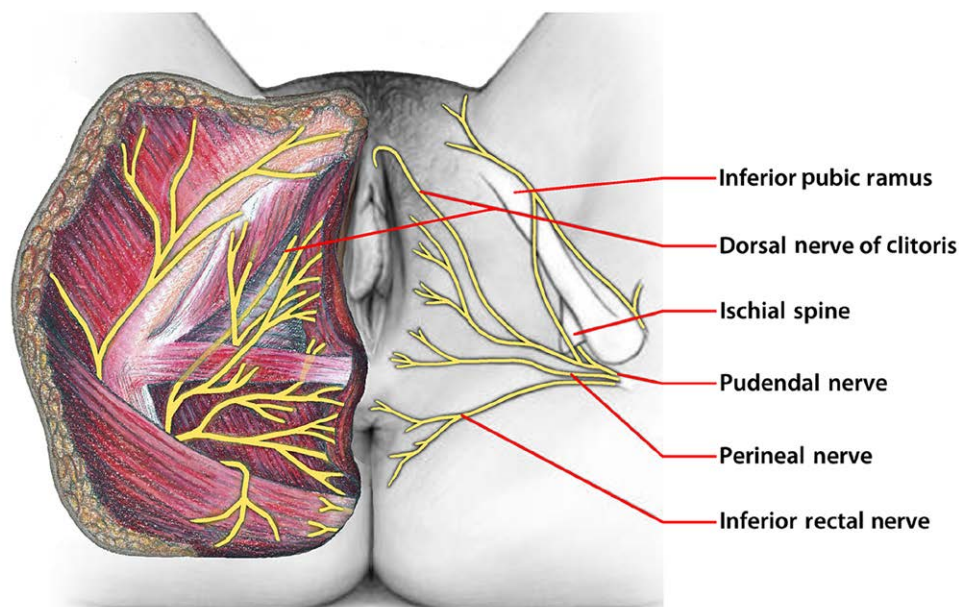


Fig. 1. Schematic anatomical overview of female genital area.

ischiocavernosus muscle-fascia is opened longitudinally just medial and parallel to the inferior ramus. Careful dissection discloses the proximal DCN, which is traced cranially partially behind the clitoral crus until it is impossible to go further. The crus is then mobilized along the upper medial border and retracted. There, the distal DCN is found and dissected caudally to meet the proximal DCN. The DCN is cut at the point where it disappears just behind the ramus inferior and transposed cranially behind the crus to reach the groin.

Both incisions are connected, and the distally cut IIN is microscopically coapted to the DCN with nylon 9.0. The external oblique fascia is (partially) closed without excessive pressure on the IIN. Closure is done in layers with a drain (Fig. 2).

RESULTS

All patients were familiar with prelesion normal genital sensations but at the time of inclusion were no longer

able to experience orgasms. IIN to DCN transfer was technically successful in all cases and performed on the left side. In 3 patients, unilateral sensations in the clitoris and small labia started 3–4 months postoperatively, which further evolved up to 18 months. The fourth patient did not develop sensations but did gain bladder function.

In all patients, lubrication was unchanged, and none experienced problems during catheterization. The scars were aesthetically acceptable, there were no complications, and no patient regretted the procedure.

Patient 1, Age 48

The first patient had an SCI (Th12-L1) after falling out of a tree at the age of 31. She had bilateral complete loss of sensation in her clitoris, clitoral hood, and labia minora. She had no sexual relationship and was not sexually active. Although able to be sexually aroused, she was unable to experience an orgasm during stimulation or intercourse. She used intermittent self-catheterization to empty her bladder.

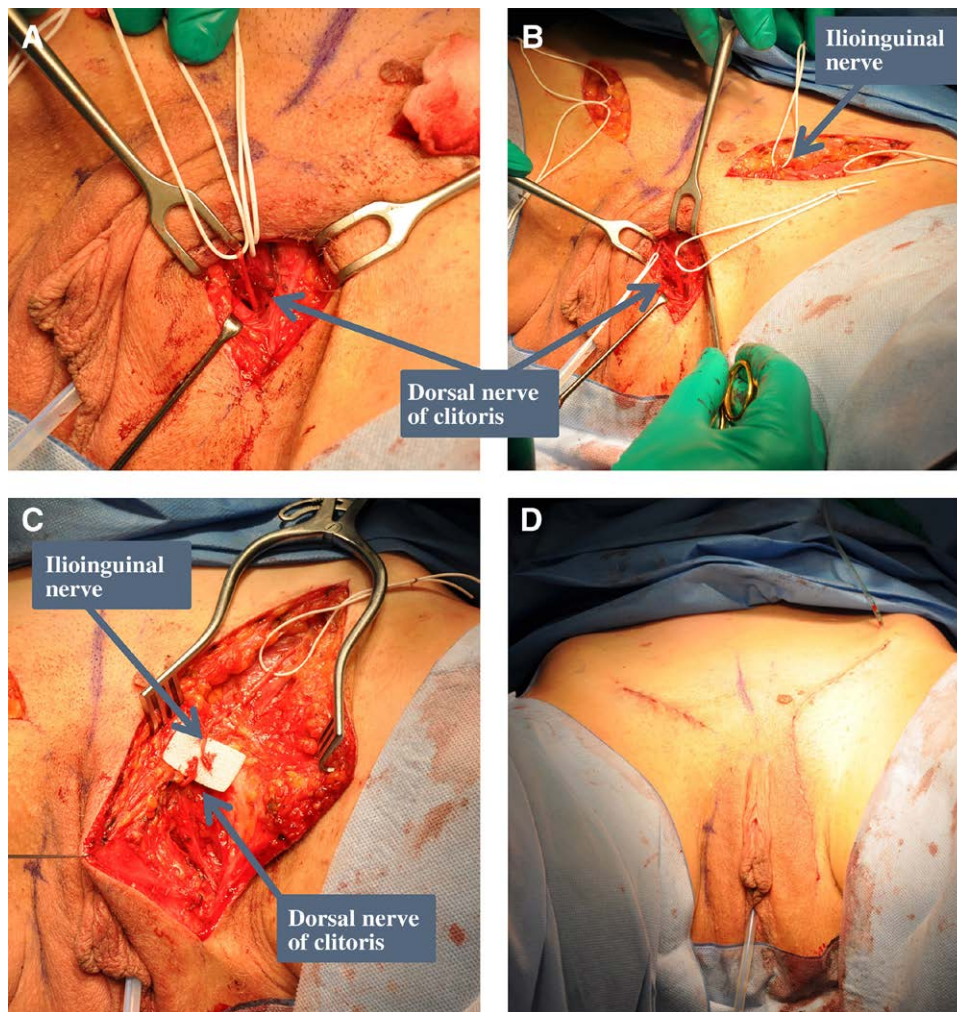


Fig. 2. The TOMAX procedure, ilioinguinal nerve to DCN transfer. A, DCN identified and dissected. B, Ilioinguinal nerve identified and dissected in the groin area. C, Nerve transfer, coaptation of the DCN to the ilioinguinal nerve. D, Postoperative situation.

Three months postoperatively, she started to experience sensations on the left side of the clitoris, clitoral hood, and small labia. When touching the clitoris, she located a sensation at the site of the clitoris (not in the groin). Surprisingly, she also experienced a minor sensation on the right side of her clitoris. These stimuli were not painful but were also not pleasant. There was a reduced sensation and numbness at the donor site.

After 18 months, she confirmed significant sensations in the clitoris and small labia. As this sensation was not very subtle and not erogenous in nature, she was not motivated to stimulate, masturbate or have sex with a partner. She had no problems with the self-catheterization. She was happy with the new sensory changes, however, because it changed her mindset in being more interested in having a relationship.

Patient 2, Age 56

The second patient had CES (L5-S1) during her pregnancy at the age of 33. She still had some sensations on the right side of the clitoris, but this was not a pleasant feeling. She had complete loss of sensation on the left side of her clitoris, clitoral hood, and small labia. Having intercourse or some kind of stimulation could not lead to an orgasm.

At 4 months, sensation was noted on the left side of the clitoris during catheterization, and initially, this was not very comfortable/a bit painful. This sensation also expanded to the right side of the clitoris. The sensations were experienced both in the left groin and in the clitoris itself. After a prolonged stimulation period, the patient experienced it as a potentially pleasant feeling. After 18 months, the clitoris was sometimes hypersensitive, leading to minor problems when wearing tight trousers. Apart from this, they were not uncomfortable. The sensation in her clitoris was evident, not erogenous, and not leading to an orgasm. No problems or pain during self-catheterization were reported.

Patient 3, Age 59

The third patient had an SCI (L1) after spinal cord infection at the age of 49. She had complete loss of sensation on the left side of her clitoris, clitoral hood, and small labia and still had minor sensation on the right side. She had intercourse but did not have any real orgasms.

In the 12 months after surgery, she gradually gained an excellent sensation on the left side of the clitoris and small labia, which was experienced in the clitoris/labia itself. The new sensations led to orgasms with her partner in specific intercourse positions, but not when masturbating. She experienced loss of sensation in the groin area. She had no problems with the self-catheterization. She reported to be satisfied/happy with the results.

Patient 4, Age 50

The fourth patient had CES (L5-S1) at 49 years of age. She had complete loss of sensation on the left side of her clitoris. On the right side, there was still some sensation. She used intermittent catheterization. Sometimes when using pressure force on the pelvic/abdominal muscles she could actively empty her bladder.

Two weeks after surgery, a surprising effect occurred: the patient was able to empty her bladder “more normal” without extra pressure and did not have to catheterize herself anymore. Unfortunately, she did not experience sensation in the clitoris, labia minora, or introitus 12 months postoperatively. This was disappointing and did not affect her sexual behavior and experiences. However, she was pleased that she did not have to catheterize herself anymore.

DISCUSSION

In women with a low SL, the absence of clitoral sensation can be of great concern, and when restored, it might positively affect their sexual health.¹ Sensory nerve transfers are novel, but can be successful, as shown in the male IIN to DNP transfer (TOMAX procedure).^{5,7}

The present pilot study shows the technical feasibility of transferring the intact IIN to the nonfunctional DCN in 4 low SL women. Excellent unilateral sensations in the clitoris and small labia developed in 3 patients, which was sexually beneficial in 1 patient. The fourth patient did not develop genital sensation but gained active control in emptying her bladder. All patients felt positive about the results and did not regret the procedure because it led to changes in all of them, whether it was a change of sensation leading to an orgasm or changing the mindset for new relationships or the fact that sensation is present now in a formerly numb area.

When interpreting these preliminary results in women, it is good to compare them with the experience in men. In the largest series to date of 73 male TOMAX patients, about one-third of patients noted positive changes with the sexual function of the penis, such as erection, ejaculation, and orgasm. Overall, satisfaction with erection, orgasm, sexual functioning, and sexual life in general increased by 58% and decreased by 8%. In addition, some patients experience urethral sensations. One patient was able to empty his bladder spontaneously, with no further need for intermittent catheterization.⁵

Despite the similarities between the penis and clitoris, there are differences. The penis has more functions than just sexual pleasure (penetration, ejaculation, more visually present, more part of the body, masculinity, and urination) compared with the clitoris. The clitoris is mainly designed for sexual arousal and is not easily visible, therefore (probably) less part of the body image.

However, with a numb penis or introitus, a man or woman does not know if the penis is inside during intercourse. Restored sensation can make them realize where the penis is, and thus, less insecure. Similarly, men can now feel when they have an erection and position in their underwear. This advantage applies less or not at all to women. Because the DNP/DCN also innervates the distal part of the urethra, urine flow can be felt into the urethra, which can be beneficial for continence (feedback). This will probably be less in women (shorter urethra).

In this study, women felt new sensations already 3–4 months after transfer. In men, it took 4–12 months.

These initial clitoral sensations are often primarily experienced as the actual sensation at the clitoris itself. In men, the first glans penis sensations are often as if the groin is being touched. These differences are probably related to the shorter reinnervation distance. The contralateral part of the clitoris also gained some sensation in 2 patients. In a unilaterally treated male patient, this is seldom seen and explained by the unilateral DNP anatomy because the axons of the right and left DNP never cross the midline.⁸

If unilateral surgery can reinnervate both sides of the clitoris, future bilateral procedures might be unnecessary. In men, bilateral surgery is executed if possible and can lead to a full-glans penis sensation.

It is good to realize that apart from transmitting penile sensory impulses to the brain, both DNPs play a crucial role in reflex erections through the sacral (S2–S4) reflex arc, which can be intact or disturbed in patients with low SL. This means that even patients with a low SL and no sensation in the penis can still have signs of remaining DNP function. Therefore, cutting one or both DNPs for the TOMAX procedure might interfere with reflex erections. In the male preoperative workup, this sacral reflex arc is measured using a bilateral needle-EMG bulbocavernosus reflex (BCR) measurement. This helps decide whether to operate unilaterally or bilaterally to preserve reflex erections if present.⁹

Analogous to this, clitoral stimulation induces reflexive lubrication. By operating unilaterally, the contralateral hemireflex arc remains intact, preserving reflex lubrication. All women had preserved lubrication pre- and post-operatively, indicating that besides reflex lubrication, there is also a psychogenic pathway which is mostly intact in low lesion women.^{10,11} In the future, BCR measurements might also be useful in female patients.

The results in male patients⁵ showed that age is the most significant predictor of sensation and sexual improvement. This is plausible because nerve regeneration and brain-plasticity are inversely related to age. Male patients aged older than 50 years did not regain sensation after nerve transfer.

In the current study, female patients were of advanced age (48, 50, 56, and 59 years) and thus, less likely to develop sensation and sexual gain. Nevertheless, sensation developed in 3 of 4 women and improvement in sexual function was seen in 1 patient. This may be due to the shorter reinnervation distance; nerve regeneration has a greater chance of reaching the end organ when compared with men. Of interest is the higher satisfaction rate in male patients with SB.⁵ This might be explained by the fact they have no reference because they had never experienced sensation before. Patients with SCI/CES, on the contrary, might compare the regained sensation to the situation before trauma and thus may be less satisfied. In the present study, only patients with SCI and CES were included, which may have affected the outcomes.

Overall, regaining genital sensation in men and women might have different outcomes, which is important when managing patient expectations. We tell future patients

that new sensations are likely to increase awareness of the genital region, contributing to their body image and the feeling of being more “complete.” Due to gained vaginal sensation, the perception of intromission can contribute to arousal. Probably, erection of the clitoris might be easier to maintain, like in male patients, making it more susceptible for touch. Orgasms might also be possible, as we saw in one patient. All these aspects can make patients more confident.

Bowel and bladder incontinence during intercourse can be bothersome. Changes in continence will (probably) not be addressed with this nerve transfer and were not seen in these patients. Although, we can speculate that increased sensation can make the patient more aware of being incontinent at moments of intimacy.

Female orgasm occurs rarely in patients with lesions above L2.¹² Restoring sensation, however, might open new pathways as we saw in 1 patient with an L1 lesion who was able to experience orgasm with some effort.

One patient was able to empty her bladder more normally 2 weeks after surgery. Increased sensation cannot play a role because reinnervation takes months to occur and she ultimately did not gain sensation. How is that possible? In patients with SCI, an overactive external urethral sphincter (EUS) can contribute to difficulties in emptying the bladder.¹³ There might be 2 reasons for this.

Disruption of descending inhibitory fibers from the brain to the sacral spinal center in SCI causes spasticity, increased/pathological reflexes, and weakness in the urinary tract.¹⁴ As a result, the bladder and sphincter lack coordination and both exert overactivity (detrusor sphincter dyssynergia).¹⁵ In addition, the activation of the BCR by stimulation of the genitalia might also contribute to EUS strength. After sensory genital stimulation, the afferent DNP/DCN and perineal nerve send their message to S2–4, whereas the efferent motor neurons via the pudendal nerve supply the ischio-bulbocavernosus musculature but also the EUS and anal sphincter. Conditional clitoral and perineal stimulation has been shown to strengthen the EUS and improve pure stress urinary incontinence.¹⁶ Frequent genital vibratory stimulation mechanical nerve stimulation may help to tone and strengthen the EUS muscle via the BCR.¹¹ We can postulate that if the BCR can contribute to EUS strength, blocking the afferent BCR route by dividing the DCN (like in the TOMAX procedure) might do the opposite: less “training” of the EUS and, thus, a more relaxed sphincter resulting in more ease of bladder emptying. Why this only occurred in 1 patient, we do not know, but experience with more patients might identify a subgroup.

The incidence of SCI is estimated at 40 per million in the United States¹⁷ and the prevalence at 223–755 per million worldwide.¹⁸ The prevalence of SB is 3.1 cases per 10,000 aged 0–19 years in the United States.¹⁹ This means that the female TOMAX procedure can restore (erogenous) genital sensation in a large number of patients.

This pilot study has limitations owing to the small number of patients, advanced age, and limited psychosocial evaluation.

CONCLUSIONS

Although there is only limited experience so far, IIN-to-DCN transfer is a promising new technique that can restore sensation in the genital area and might affect bladder function in women with low SL. Whether the new sensations will increase quality of life or sexual health remains uncertain, but we believe that they must have that potential. Restoring genital function and sensation is an upcoming new era and should be part of the normal rehabilitation program worldwide.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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